THE UNIVERSITY OF ALBERTA

THE ABUNDANCE AND DISTRIBUTION OF PASSERINE BIRDS IN BOREAL FOREST HABITATS OF THE WESTERN GREAT SLAVE LAKE REGION.

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled The Abundance and Distribution of Passerine Birds in Boreal Forest Habitats of the Western Great Slave Lake Region submitted by Ludwig Friedrich Norbert Carbyn in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

An attempt was made in this study to determine the abundance and distribution of the passerine birds nesting in various boreal forest habitats. The field work was carried out during the summers of 1965 and 1966 in the region west of Great Slave Lake, N.W.T.

A Spot-mapping technique was applied to determine the number of singing passerine males on five 25-acre plots. Investigations were carried out to determine the optimum time in the morning and the dates during which the counts can most effectively be conducted at latitudes 61-63°N.

Stages of the breeding cycles of passerines were determined from data on nests found, and from gonadal studies of Slate-colored Juncos (*Junco hyemalis* L.). Sparrows (Fringillidae) and American Robins (*Turdus migratorius* L.) were early nesters, their breeding cycles extended from 26 May to 27 June. The breeding cycles of the late nesters, which included other thrushes (Turdidae), warblers (Parulidae) and kinglets (Sylviidae), extended from 5 June to 7 July. Maximum early morning singing activity for sparrows and warblers was from 0100 to 0430 hours.

The number of breeding passerine birds present during the breeding season on the areas sampled varied from 124 to 336 birds per 100 acres. Slate-colored Juncos were the most abundant species on four out of five of the plots sampled. The number of species of breeding passerine birds

varied from 6 to 11 on the plots. Non-passerine and non-breeding passerines on the plots varied from 4 to 8 species.

Biomass values of the passerine bird populations on the plots ranged from about 2700 to 5500 grams per 100 acres. On three of the five plots, populations of the fringillids contributed most to total avian biomass. Thrushes contributed the highest percentage of biomass on the remaining two plots.

For each plot indices of similarity and diversity were calculated. A statistical analysis of the data indicated that the territorial males of the same species were spaced in a nearly uniform pattern within the plant communities of a 25-acre plot. The distribution of Slate-colored Juncos and Chipping Sparrows overlapped considerably on most plots.

The northern ranges of seven species were extended in the region north-west of Great Slave Lake. Of the 89 common breeding species, 9 per cent were of South American origin, 18 per cent of Old World origin, 23 per cent of North American origin and 50 per cent of an unanalysed element.

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INTRODUCTION

My objectives in this study were: (1) to determine the optimum time of day, and period within the breeding season for counting passerine bird populations; (2) to determine the abundance and distribution of passerine breeding birds in different boreal forest habitats.

I used the singing activity of the males as a means of determining the numbers of birds on plots. The importance of the singing activity to territorial behaviour, and hence the number of individuals in an area, was first described in detail by Howard (1920). Its significance has since been widely discussed by ornithologists. However, very little is known about the variation in daily and seasonal activity patterns at different latitudes. Because I based my census work on the singing activity of males, I investigated the activity patterns of the passerines both on a seasonal and daily basis.

Bird populations are often expressed as the number of birds of each species per 100 acres. In terms of productivity, biomass values are much more meaningful than numerical abundance. Therefore I calculated the biomass of the passerine breeding birds that were present on the plots. Furthermore, dispersion patterns and habitat selection of the birds on the plots were determined from the results of the censuses.

I included a zoogeographical analysis to describe the avifauna in relation to its probable origins. With increased warming trends of the northern regions (Nero, 1963), the

various components in this avifauna could be expected to shift in the future. Such changes have been observed by residents in the area within the last 15 years. However, information of this nature indicates only overall trends and is not based on quantitative data.

I hope that this study will be used as a basis for further ecological research. Detailed studies of ecosystems should include the determination of the energy flow and productivity at all the trophic levels within the ecosystem. International agencies, namely subcommittees of the International Biological Program, have been recently established to evaluate the productivity of habitats on a worldwide scale. The results of this study could be used to compare the avian productivity of the boreal forest in the Great Slave Lake region with other regions at different latitudes.

LITERATURE REVIEW

Considerable information has been published on methods and results of studying avian populations. Usually the methods employed vary with different species and with different areas.

Linsdale (1924) used frequency indices to show relative abundance of birds in different habitats. This method was widely employed (Dice, 1930; Lack and Venables, 1939; Rodgers and Sibley, 1940; White, 1942). There are other methods for describing the relative abundance of birds, such as the number per unit time (Lay, 1938; Parnell and Quay, 1964) and the census along roads (Leopold, 1942; Howell, 1951). These methods are based on the assumption that the more abundant

species will appear more frequently in samples than the less abundant species. An obvious source of error in this assumption is the different degree of conspicuousness of species. Attempts to overcome this difficulty are described by Colquhoun (1940), Enemar (1959), and Naumov (1965).

Transect and plot censuses are absolute census methods. The plot census method has been widely applied and forms the basis of the yearly breeding-bird censuses of North America, first organized in 1937 by the National Audubon Society (Hickey, 1937).

A detailed historical development to 1944 of avian census methods is described by Kendeigh (1944). A comparison and description of the different methods of census are outlined by Lack (1937), Kendeigh (1944),Nordberg (1947), Bond (1957) and Naumov (1965). Naumov (*op. cit.*) describes a method of transferring relative abundance data to absolute figures.

Several avian population studies in northern forests have been conducted in Scandinavia (Palmgren, 1931, 1933; Siivonen, 1948; Enemar, 1959, 1963; Tenouvo, 1966). The Russian literature on bird population studies listed in Biological Abstracts is quite extensive. Most studies on passerines in the North American boreal forest have been conducted in conjunction with spruce budworm (Choristoneura fumiferana Clem.) outbreaks (Kendeigh, 1947; Hensley and Cope, 1951; Stewart and Aldrich, 1952; Dowden, Jaynes and Carolin, 1953). The only previous study of bird populations within the Great Slave Lake region is that of Stewart (1955).

STUDY AREA

General description

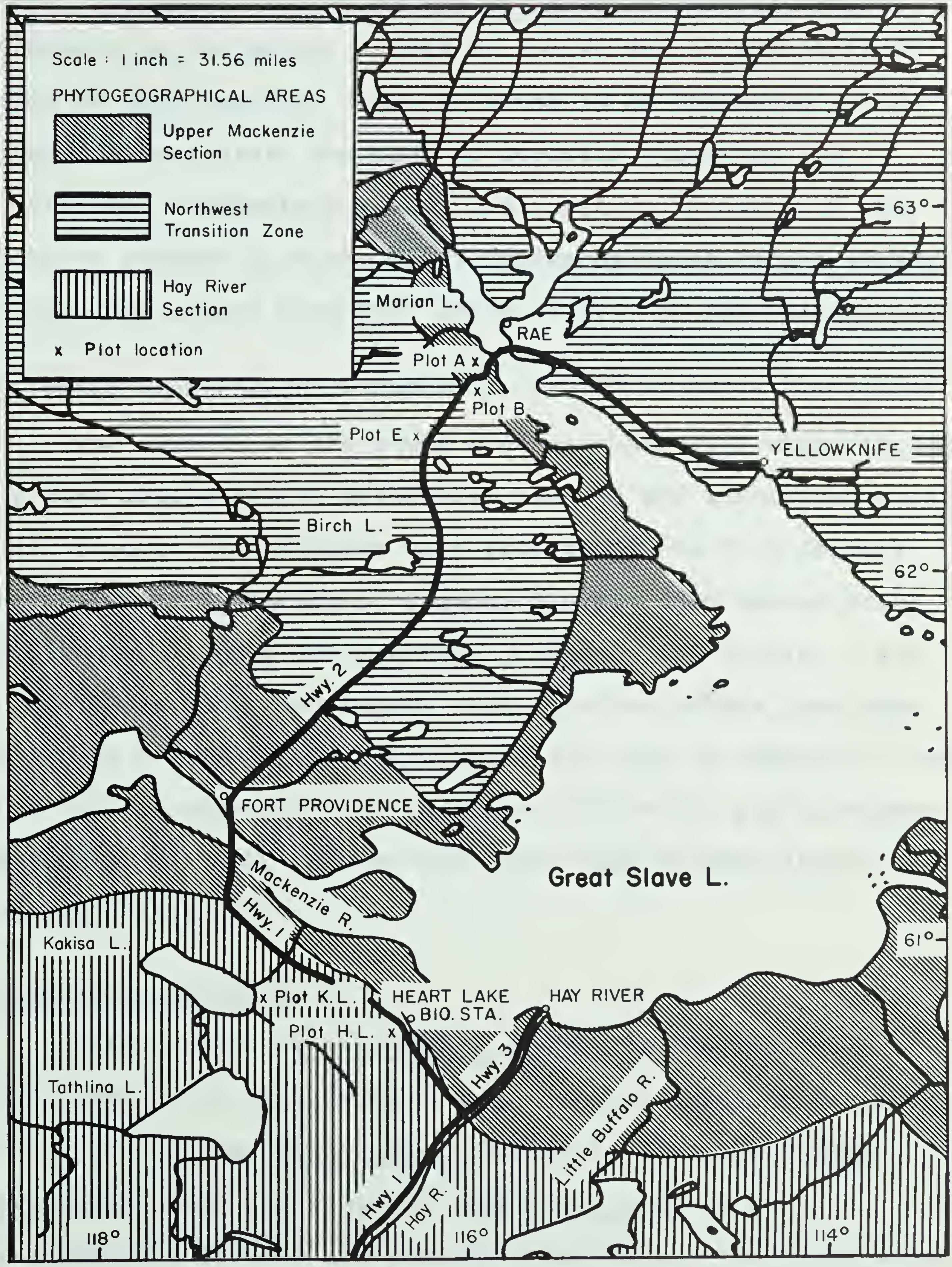
Field work was carried out along the Mackenzie-Great Slave Lake Highways of the Northwest Territories. The locations of the plots are shown in Figure 1.

Plot HL is the most southerly plot. It is located near the Heart Lake Biological Station (Lat. 60°51'N; long. 116' 38'W). Plots KL, E, B and A are located 31, 170, 181 and 188 miles from plot HL respectively. The mileages in each case refer to points which are located progressively northward on the Mackenzie-Great Slave Lake Highways.

North American biogeographical areas are variously defined. Some of the major works consulted were Harper (1931), Daubenmire (1938), Pitelka (1941), Dice (1943), Moss (1955), Kendeigh (1961) and Shelford (1945, 1963). Depending on the system of classification used, the study area in question falls within the boreal forest life zone (subdivisions - Hudsonian and Canadian) of Shelford (1963); the coniferous forest biome of Kendeigh (1961); and the Hudsonian biotic province of Dice (1943).

Rowe's (1959) classification based on physiographic and phytogeographic criteria was found most useful in describing the different sections within the study area (Fig. 1). He classified the area as the boreal forest region, and subdivided this region into sections. According to this classification Plots A and B are located within the Upper Mackenzie Section. This is a region of Devonian and Cretaceous bedrock buried under alluvial and glacial materials (Rowe, 1959). Plot E

Figure 1. Map of the western region of Great Slave Lake showing locations of the study plots along the Mackenzie-Great Slave Lake Highways in N.W.T. (Modified after Rowe, 1959).


Scale : 1 inch = 31.56 miles
PHYTOGEOGRAPHICAL AREAS
Upper Mackenzie Section
Northwest Transition Zone
Hay River Section
x Plot location
Marian L.
RAE
Plot A x
x Plot B
Plot E x
YELLOWKNIFE
63°
Birch L.
62°
Hwy. 2
FORT PROVIDENCE
Great Slave L.
Mackenzie R.
Hwy. 1
Kakisa L.
61°
x Plot K.L.
HEART LAKE BIO. STA.
HAY RIVER
Plot H.L. x
Hwy. 3
Tathlina L.
Little Buffalo R.
Hwy. 1
Hay R.
118°
116°
114°

is within the Northwest Transition Section. Adjoining the Upper Mackenzie Section is the Hay River Section (Alberta Plateau) to the south. Plots HL and KL are at the northern edge of this section, (Fig. 1) which is an extension of the great central plain composed of Devonian limestone and Cretaceous sedimentary rock. The northern boundary of the Alberta Plateau is marked by a series of north facing escarpments that extend from Fort Smith, N.W.T. to Fort Liard, B.C.

Climatic conditions

The climate of the study area is subarctic, characterized by long cold winters, brief warm summers and light precipitation. Mean monthly temperatures vary from about -15 F in January to 60 F in July (Atlas of Canada, 1957). Mean annual precipitation is only 10-15 inches (Kendrew and Currie, 1955). During June, July and August precipitation totals less than 3 inches (Kendrew and Currie, 1955). The days in summer are marked by long photoperiods. At latitude 62°30'N the sun at summer solstice (21 June) sets at 2203 and rises at 0200 (Atlas of Canada, 1957).

Dominant vegetation

Black spruce (*Picea mariana* Mill.) is the most common tree species of the region. Other locally abundant conifers are white spruce (*Picea glauca* Moench.), jackpine (*Pinus banksiana* Lamb) and tamarack (*Larix laricina* Du Roi). Although the forests are primarily coniferous there are widespread deciduous stands, both mixed and pure. This is particularly true of an area north to northeast of Fort

Providence. With increased latitude the closed forest-moss community changes into open lichen-woodland areas that eventually merge into tundra (Rowe, 1959). Permafrost extends from the Arctic regions into more southerly latitudes. Its effects on the plant community are considerable (Péwé, 1957; Viereck, 1965).

With the exception of geological survey lines (Fig. 12) and a few roads most areas within the region are practically unaltered by man. Fire occurs naturally throughout the region and is important in the stages of plant succession (Oosting, 1956).

From an overall floristic viewpoint, Plots HL and KL are found within the true "Boreal Forest", whereas Plots E, B, and A have a characteristic "Open Subarctic Woodland" floral composition (La Roi, pers. comm.).

A more detailed description of the locations and general permafrost conditions of the individual plots sampled is given below. All compass bearings listed refer to magnetic bearings. The permafrost levels were examined only to a level of 3.5 ft beneath the ground surface.

<u>Locations of specific plots</u>

Plot HL (Lat. 60°52'N; long. 116°39'W) is located immediately west of the Heart Lake road and approximately one quarter of a mile south of the Mackenzie Highway. No permafrost samples were taken on this plot.

Plot KL (Lat. 60°56'N; long. 117°23'W) is located 3 miles southwest of Lady Evelyn Falls. A geological survey line (200° compass bearing) forms the base line of this plot.

The boundary closest to the Kakisa road is approximately 250 ft from the edge of the road. There was no evidence of permafrost to a depth of 3.5 ft at the locations sampled on this plot.

Plot E (Lat. 62°35'N; long. 116°23'W). The baseline (228°) is 300 ft from the Great Slave Lake Highway and parallel to it. It formed the boundary of the plot which is nearest the road. No permafrost was found to a depth of 3.5 ft.

Plot B (Lat. 62°43'N; long. 116°3'W). The plot boundary nearest the Great Slave Lake Highway is approximately 320 ft from it. The compass bearing of the baseline is 182°. A check on permafrost levels revealed a very shallow frost free layer of about 1 ft in the black spruce zone whereas no permafrost to a depth of 3.5 ft occurred in the predominantly white spruce stand.

Plot A (Lat. 62°47'N; long. 116°4'W), the northern most plot, was sampled in 1965 (Plot A-I) and in 1966 (Plot A-II). It is located along a winter tractor road. The base line (300° compass bearing) is 1200 ft from the main road. Permafrost levels varied from 1.5 ft to 3.5 ft and in certain areas no permafrost could be detected.

METHODS

Plot surveys

All plots were laid out in 1050 ft squares and subdivided by gridlines. A 100 ft steel surveyor's tape and a Silva compass were used in surveying the plots. Geological survey lines were used as base lines (Fig. 12) for all plots,

except Plot HL. To avoid "edge effect" the plots were located 100 to 1200 ft away from the main roads. An attempt was made to select areas of uniform vegetation; however, this was difficult to do with plots of this size. An aerial reconnaisance conducted near Rae in the winter of 1965 yielded much better results in selecting plots of fairly uniform vegetation cover than was possible with ground surveys. Plots E and B were selected in this manner.

Each plot was divided by seven parallel lines which were crossed by seven other parallel lines running at right angles to them and forming a grid pattern (Fig. 2). The lines closest to the boundaries were 75 ft from them, and the remaining five lines were spaced 150 ft apart. Thus, each plot was divided into 28 smaller sections at the outer edge of the plot and 36 larger squares within the plot (Fig. 2).

The intersections of this grid system were marked with red surveyor's tape and the nearest tree numbered with a "Dymo-set" label marker. The lines oriented at right angles to the base line were lettered from A to I and the intersections numbered from 1 to 8 (Fig. 2). Grid maps for each plot were mimeographed and the intersections numbered and lettered in the same order as on the plots.

Habitat analysis

A general habitat analysis for all plots was carried out using a modification of the method suggested by Elton and Miller (1954). At each sampling location the vegetation was divided into three layers. The ground layer included all the vegetation up to 3 in. The shrub stratum included all the

vegetation from 3 in. to 6 ft above ground level. All trees and bushes taller than 6 ft were included in the canopy layer.

Intersections of the grid lines were used as sampling locations. All 49 intersection points were sampled on plots with widely diversified plant communities. However, on plots with few major communities the intersection points of every second grid line were sampled. Plants that could not be identified in the field were collected and later identified in the laboratory. Botanical names were taken from Moss, 1959.

Quantitative measurements of the dominant plant cover were limited to rough percentage classes of cover of the dominant plants. All the conspicuous plant species present within a radius of 6 ft from the marker tree were included in the sample. The vegetation maps (Figs. 3 to 7) were drawn from the results of this habitat analysis.

Daily activity studies

Five early morning activity surveys were conducted in the middle of June at Rae. Each survey was conducted at a specific point on the study area to determine the onset, intensity, and duration of early morning singing activity of the common species.

The surveys were begun between 2400 and 0030 hours, and ended approximately one half hour after termination of the last regularly recurring song of the species investigated. In each case an individual closest to the sampling location was used as representative of that species.

I decided to conduct these studies at a time in the nesting season when the peak of singing activity could be

expected,(Nice, 1937). The times chosen were from late nest building to incubation stages, the dates being 11, 12, 25, 26 and 28 June.

The survey was carried out on days during which environmental conditions were similar to those when a regular count was conducted on the study plots. Counts were not taken on windy or rainy days. Variations in humidity, calmness and degree of cloudiness were noted in general descriptive terms only.

Seasonal activity studies

Seasonal advancement of the breeding cycle of the various passerines was determined by collecting nesting data from all the nests found. The nests were examined to record breeding chronology. I recorded this information on standard nest record cards.

Gonadal studies were carried out on Slate-colored Juncos (*Junco hyemalis* L.) to determine the exact onset of the breeding cycle of this species which arrives early on the breeding area.

A collection of 58 Slate-colored Juncos was made over a period covering late spring migration, pre-nesting, nest building, and egg laying stages. A sample of 2-6 birds was collected at least every 5 days from 9 May to 15 June in 1966 at Rae.

The gonads were fixed in Bouin's (picro-formolacetic) solution. The length of the left testis was measured to the nearest 0.5 mm, then sectioned at 7μ and stained in Haidenhain's Iron Haematoxylin.

Developmental stages were classified according to a

modification of the systems used by Blanchard (1941) and Lewin (1963).

Stage 1 - inactive condition, lumen if present small, no sperm present.

Stage 2 - slight development, primary spermatocytes begin to appear, no sperm present.

Stage 3 - increased development of germinal elements of tubules.

Stage 4 - spermatids in various stages of metamorphosis and maturing sperm bundles along the edge of the lumen. Mature sperm have their heads pointing away from the lumen.

Stage 5 - tubules enlarged to their greatest size. Fully metamorphosed sperm are closely packed in bundles of about 7-13.

Census methods

Censuses of the breeding passerine bird populations were conducted by using the Williams Spot-mapping census technique (Hall, 1964). This method is designed to record the number of territorial males present on plots.

The birds were counted while walking along one set of parallel lines at an average speed of 50 ft per minute. The average sampling time spent per plot per morning was approximately 140 minutes. The locations of all birds heard and seen on either side of the census line were plotted on maps. The locations of the birds were determined by referring to the numbered trees at grid intersections. Various symbols were used to indicate such activities as singing, nest building, fighting, courting, feeding, flying and flight direction. Sex

and age of birds seen were recorded whenever possible; juvenile or adult age categories were used. Identification of songs and calls was achieved by consulting tape recordings of bird songs and locating the singing males. Individual singing males were often recorded more than once if they changed their singing locations.

An important aspect of the counts was the recording of different males singing simultaneously, and often additional time was spent to locate these males.

At the end of each count the data were transposed to summary sheets. After completing all the counts on a plot, the locations of the singing males were plotted on composite maps. Different maps were used for each species. Using the cluster of points so obtained, and the evidence of males heard simultaneously, lines delineating territories were drawn around each singing male. If the territory of a male was only partly within a plot then only half a territory was listed for that male. In all the calculations of the populations on the plots it was assumed that each singing male represented a pair of breeding birds.

Counting was carried out in the early morning on generally clear and calm days. Counts were conducted on at least three consecutive days. This was necessary since, due to predation and other factors, territories change during the breeding season (Enemar, 1959). Therefore, if the counts were widely spaced it would have been difficult to plot the exact number of the territories. At least seven counts were taken on each plot.

Plots KL, HL and A-I were sampled in 1965. During the summer of 1966 Plots E, B, and A-II were sampled. Because the populations on Plot A were different in the two seasons, I have analysed the results separately.

In addition to the territorial birds seen and heard, all non-territorial birds (migrating, casual and regular visitors) were recorded. Mammals seen on the plots during the census were also recorded.

RESULTS

Habitat analysis

The distribution of the major plant communities on the five plots is shown in Figures 3 to 7. These communities are frequently referred to as zones in the description of the plots. No detailed quantitative methods of vegetation analysis were employed. Below are listed the vegetation cover and general topography of the five plots.

Plot HL: In Figure 3 the main zones of this plot are outlined. Several low ridges, probably glacial in origin, traverse this predominantly dry open jackpine stand (Zone C). This habitat is illustrated in Figure 8. Trembling aspens (*Populus tremuloides* Michx.) are scattered in the central portion (Zone B) of the plot. In Zone D, approximately 2.0 acres, there is an almost pure stand of tall aspen (Fig. 9).

The shrub stratum throughout the plot is sparse, consisting of ground juniper (*Juniperus communis* L.), creeping juniper (*Juniperus horizontalis* L.), rose (*Rosa* spp.), cinquefoil

(Potentilla fruticosa L.), buffaloberry (Shepherdia canadensis Nutt.), low bush cranberry (Viburnum edule Raf.), and scattered saplings of white spruce and trembling aspen. No jackpine saplings were found on the plot.

The ground cover consists mainly of jackpine needles, feathermoss (Hylocomium spp. and Pleurozium spp.), common bearberry (Arctostaphylos uva-ursi L.), and various grasses.

Other plants present but rare are paper birch (Betula papyrifera Marsh.), bastard toad-flax (Geocaulon lividum Richards.), northern bedstraw (Galium boreale L.), twinflower (Linnaea borealis L.), bunchberry (Cornus canadensis L.), white camas (Zygadenus elegans Pursh.), alpine bearberry (Arctostaphylos rubra Rehder and Wils.), fireweed (Epilobium angustifolium L.), Aster spp., and Campanula spp.

An area of approximately 0.75 acres in the northwestern section of the plot (Zone E) is covered by an open, black spruce-sphagnum moss bog. The shrub stratum in this section consisted mainly of common labrador tea (Ledum groenlandicum Oeder), scattered willow, and dwarf birch (Betula glandulosa Michx.).

A narrow strip, approximately 300 ft long by 75 ft wide, of dense black spruce trees extended into the mid-southwestern section of the plot (Zone A).

Plot KL: This plot showed the greatest diversity of plant communities (Fig. 4). Zone B, approximately 9.5 acres, is an open black spruce feathermoss association as described by Moss (1955). The small trees form scattered aggregates or

clumps of trees which create thickets. The ground is covered by various species of mosses, lichens (Cladonia spp.), crowberry (Empetrum nigrum L.) and bog cranberry (Vaccinium vitis-idaea L.).

Common Labrador tea and northern Labrador tea (Ledum palustre L.) small black spruce and larch trees are the main constituents of the shrub stratum. Scattered throughout this section are clumps of willows, rose, buffaloberries, blueberries (Vaccinium myrtilloides Michx.) and currants (Ribes spp.).

A sedge swamp lies within the center of the plot (Zone C). Scattered larch trees (height up to 40 ft) and black spruce trees grow around the fringes of the swamp. The shrub stratum is composed mainly of sapling larch trees, willow and birch. In spring and early summer the low areas contain small ponds which disappear towards mid-summer, and are then overgrown by grasses and sedges.

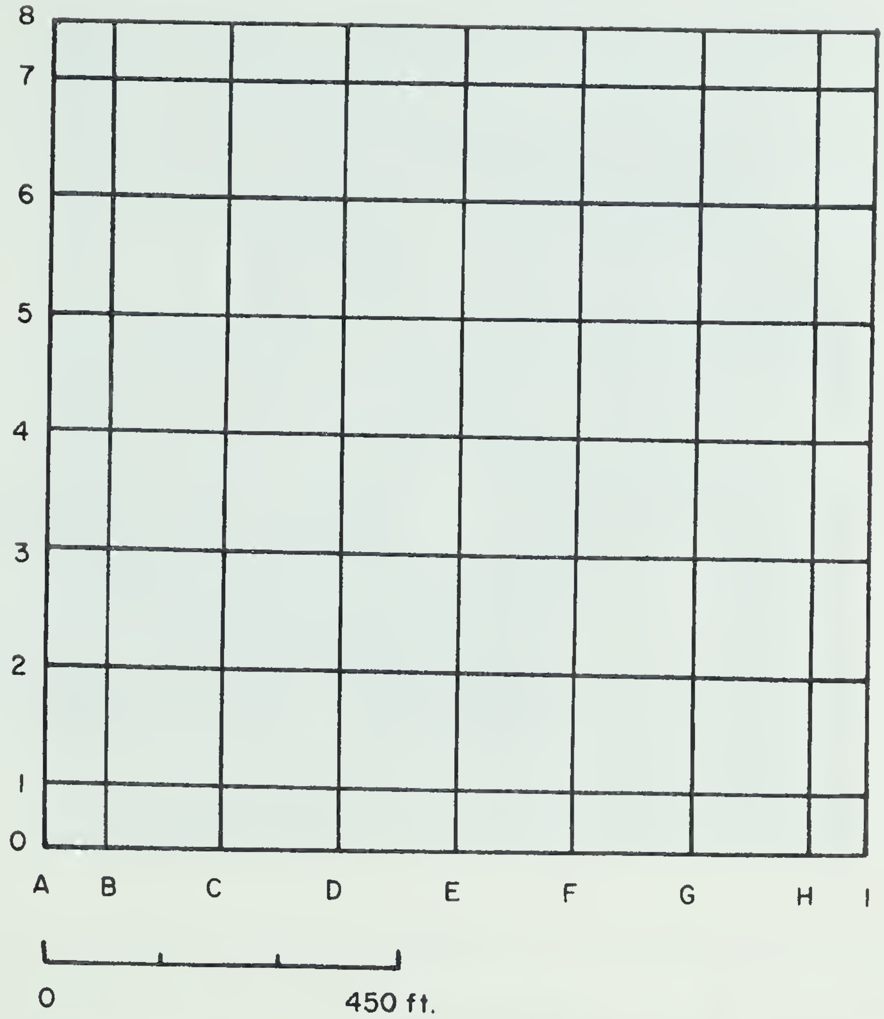
Two different stands of tall white and black spruce trees (Zone A - 1.25 acres, and Zone D - .75 acres) are located on higher well drained soil.

Zone E of approximately 9.0 acres (Fig. 10) has a vegetation cover similar to that of Zone B. However, the black spruce trees are taller and closer together forming a light canopy. The ground cover is less dense and common bearberry is more extensive in this section.

Plot E: Except for .75 acres of mature jackpine (Zone A of Figure 5) the plot has a uniform park-like black spruce cover (Fig. 11). Dead falls are evidence of fire. Lichens (Cladonia spp., Cetraria spp. and others) form the main ground vegetation.

Figure 2. Grid system used in dividing the 25 acre plots into sections. Line A to I is the base line.

Figure 3. Plan of the vegetation zones of Plot HL.
Zone A - Dense black spruce stand
Zone B - Mixed jackpine, trembling aspen stand
Zone C - Jackpine stand
Zone D - Trembling aspen stand
Zone E - Spruce bog


8
7
6
5
4
3
2
1
0
A
B
C
D
E
F
G
H
I
0
450 ft.

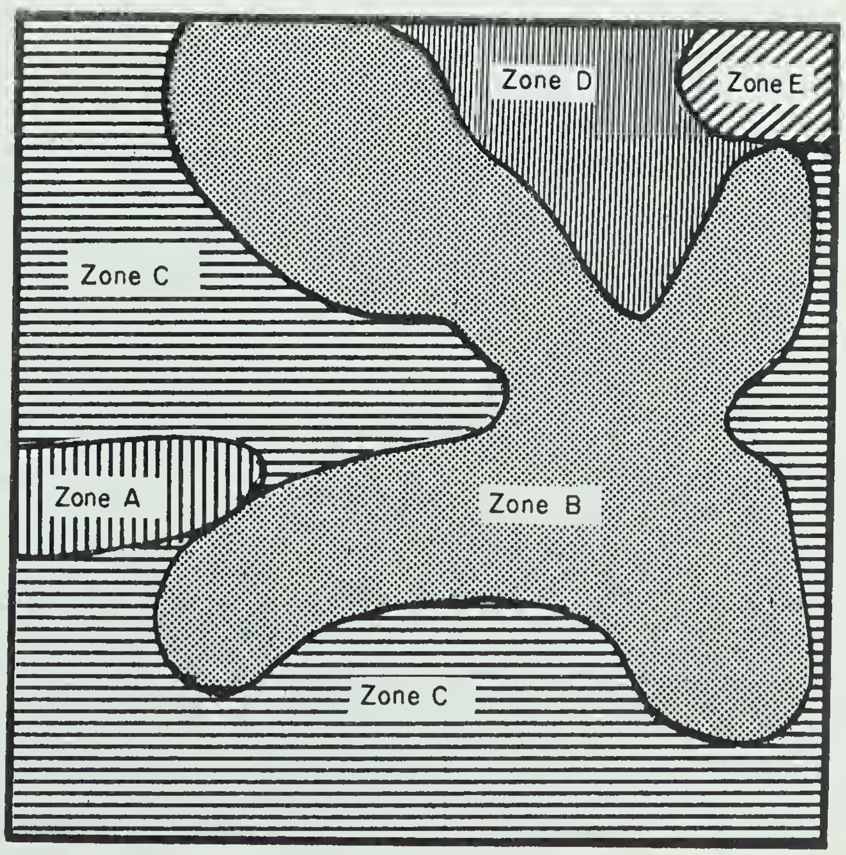
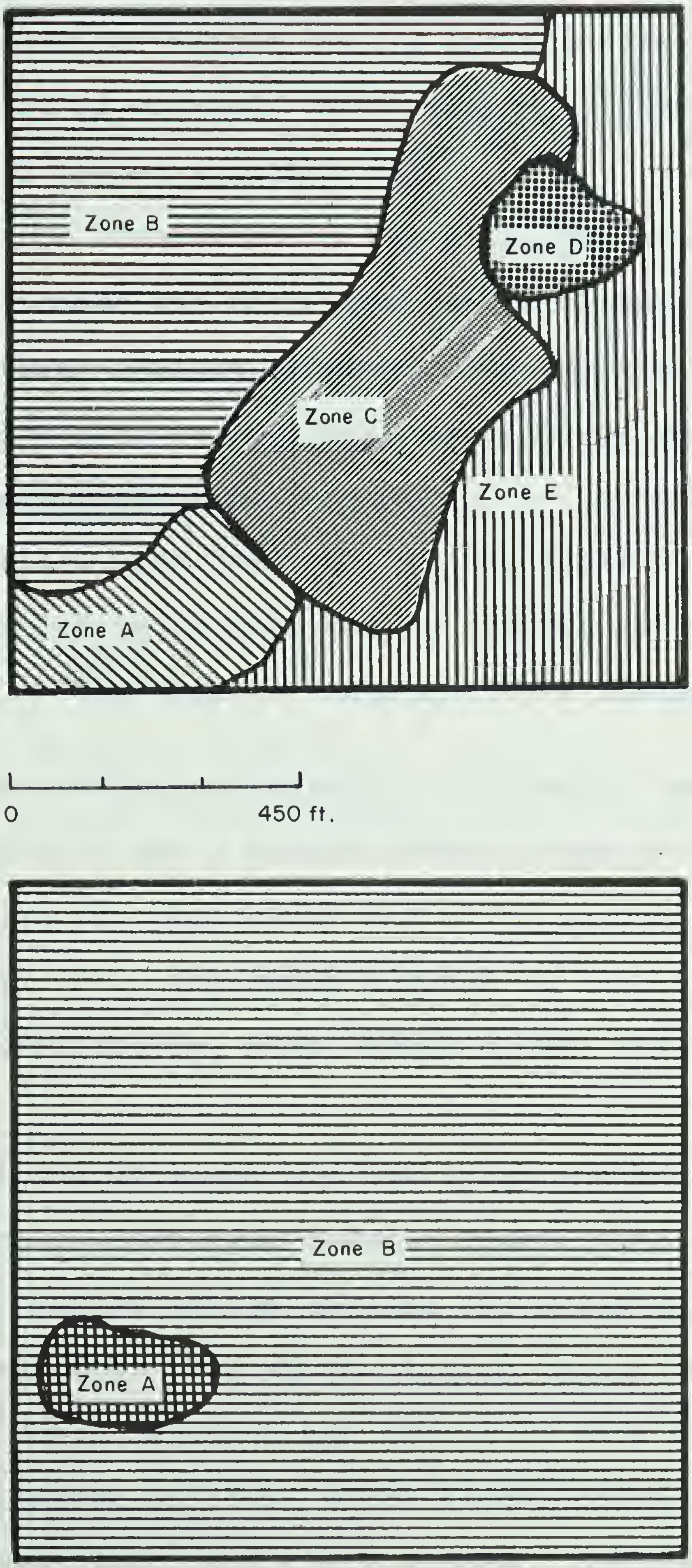

Zone D
Zone E
Zone C
Zone A
Zone B
Zone C

Figure 4. Plan of the vegetation zones of Plot KL.
Zone A - Tall mature spruce stand
Zone B - Open black spruce bog
Zone C - Sedge swamp fringed by larch trees
Zone D - Tall mature spruce stand
Zone E - Dense black spruce stand

Figure 5. Plan of the vegetation zones of Plot E.
Zone A - Mature jackpine stand
Zone B - Open black spruce-lichen stand


Zone B
Zone D
Zone C
Zone E
Zone A
0
450 ft.
Zone B
Zone A

Depressions seem to provide suitable microclimates for various mosses, as well as for scattered alpine bearberry and bog cranberry. Creeping juniper occurs sporadically. The shrub stratum consists of willows, buffaloberry, cinquefoil, rose, dwarf birch and common labrador tea.

Other plants identified on the plot, but contributing little to the plant biomass are fire weed, white camas, twinflower, bastard toad-flax, various sedges, common pink wintergreen (Pyrola asarifolia Michx.), Dryas spp., Aster spp. and the legume Hedysarum alpinum L.

Soil profiles were taken at various locations. A thick humus layer of 2.5 ft is followed by a dense grey clay layer of about 1 ft. This soil is underlain by a limestone formation.

Plot B: An area of approximately 5.0 acres of the southwestern section of the plot has a gentle north-easterly facing slope (Zone A). A mature, open black and white spruce stand covers this area (Fig. 12). The shrub stratum is limited to scattered cinquefoil, buffaloberry, rose, dwarf birch, and common labrador tea.

The remaining 20 acres are low lying and have a uniform black spruce-moss vegetation cover. Trees in this section are predominantly shallow rooted because the permafrost comes close to the surface. The shrub stratum varies considerably in density. Common labrador tea dominates this stratum. Other shrubs include willows, dwarf birch, buffaloberry, cinquefoil, young larch and black spruce. Lichens (Cladonia spp. and others), various mosses, crowberry, blueberry, bog cranberry,

alpine bearberry and cloudberry (*Rubus chamaemorus* L.) form the main ground cover. Other plants present are cottongrass (*Eriophorum* spp.), white camas, twinflower, common horsetail (*Equisetum arvense* L.), common butterwort (*Pinguicula vulgaris* L.), mitrewort (*Mitella nuda* L.) and small bog cranberry (*Vaccinium oxycoccus* L.).

Plot A: Zone A (2.5 acres) is a mature jackpine stand (Fig. 7). There is no understory except at the edges of the stand. The ground cover consists mainly of lichens (*Cladonia* spp., *Cetraria* spp. and *Peltigera* spp.). A few isolated bog cranberries and crowberries are present.

An area of 4.5 acres (Zone C) of the plot, is very swampy in which larch, willow, black spruce, paper and dwarf birch are common. Sphagnum moss, feathermoss, cloudberry, bog cranberry, crowberry and lichens, mainly *Cladonia* spp., form the ground vegetation. The main proportion of the shrub stratum is composed of both common and northern Labrador tea, leatherleaf (*Chamaedaphne calyculata* Moench.) and *Andromeda* spp. Other plants identified but adding little to the overall plant biomass are cotton grass, *Campanula* spp., *Juncus* spp., cinquefoil, blueberries and bog cranberries. Zone B, approximately 18 acres, is an open black spruce-sphagnum moss bog (Fig. 13). The most striking structural feature is the presence of uneven sphagnum mounds. The shrub stratum and ground cover is similar to that of Zone C. However, in this zone the plants of the heath family are more widely distributed.

Figure 6. Plan of the vegetation zones of Plot B.
Zone A - Tall open spruce stand
Zone B - Dense black spruce stand

Figure 7. Plan of the vegetation zones of Plot A.
Zone A - Mature jackpine stand
Zone B - Open black spruce bog
Zone C - Black spruce-willow swamp

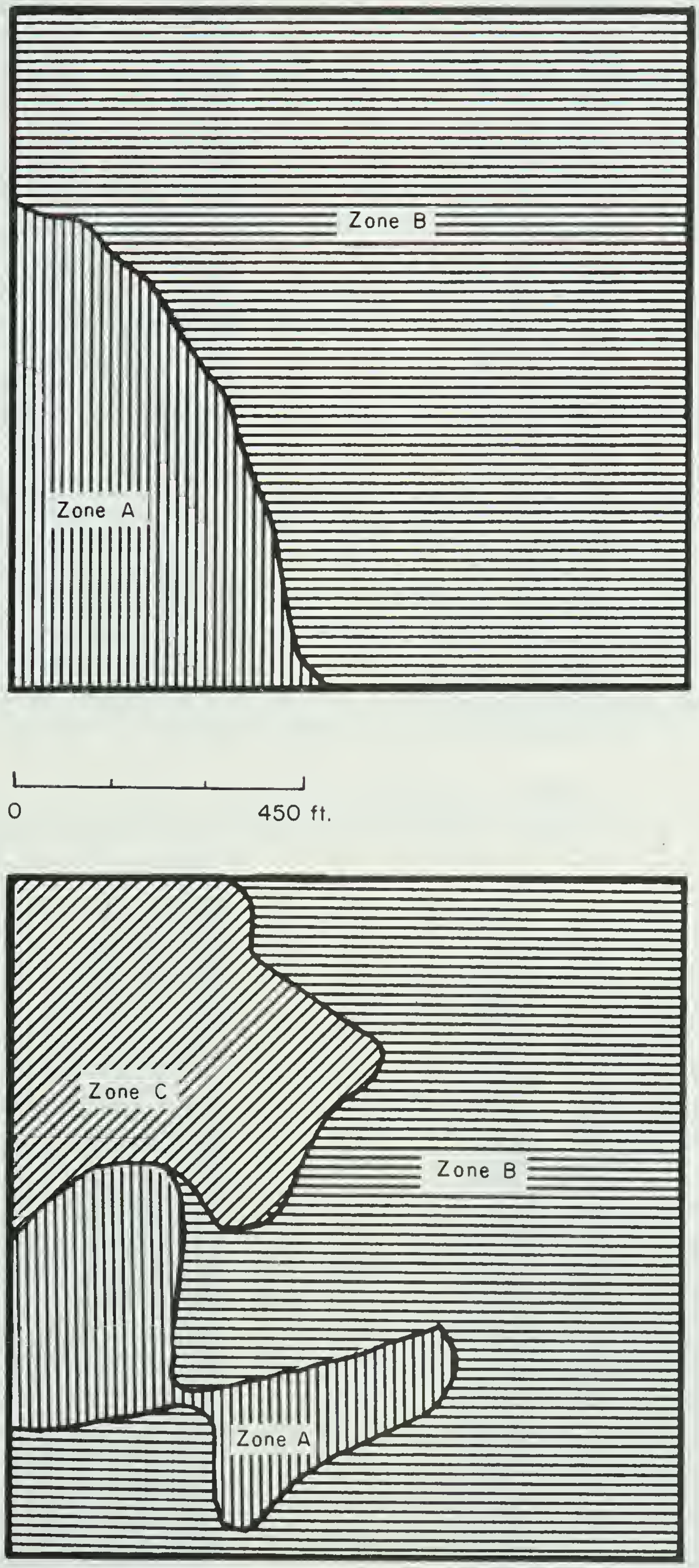

Zone B
Zone A
0
450 ft.
Zone C
Zone B
Zone A

Figure 8. Upper left. Zone C of Plot HL, showing a mature jackpine stand.

Figure 9. Upper right. Zone D of Plot HL, showing a trembling aspen stand.

Figure 10. Lower left. Zone B of Plot KL, showing an opening in a dense black spruce stand.

Figure 11. Lower right. Zone B of Plot E, showing an open park-like black spruce stand.

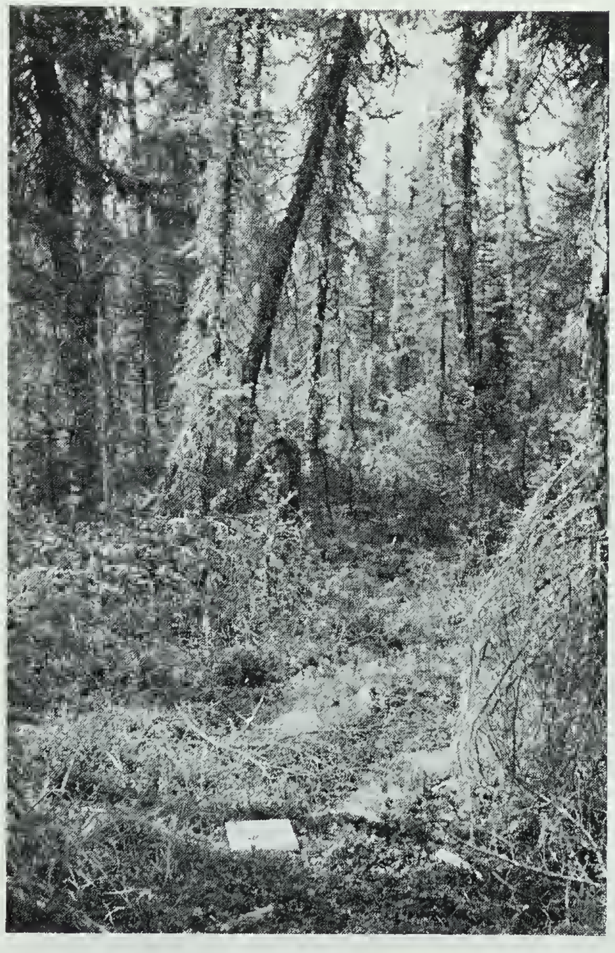


Figure 12. View of the base line and portion of zone A of Plot B, showing a tall open spruce stand in spring, 12 May.

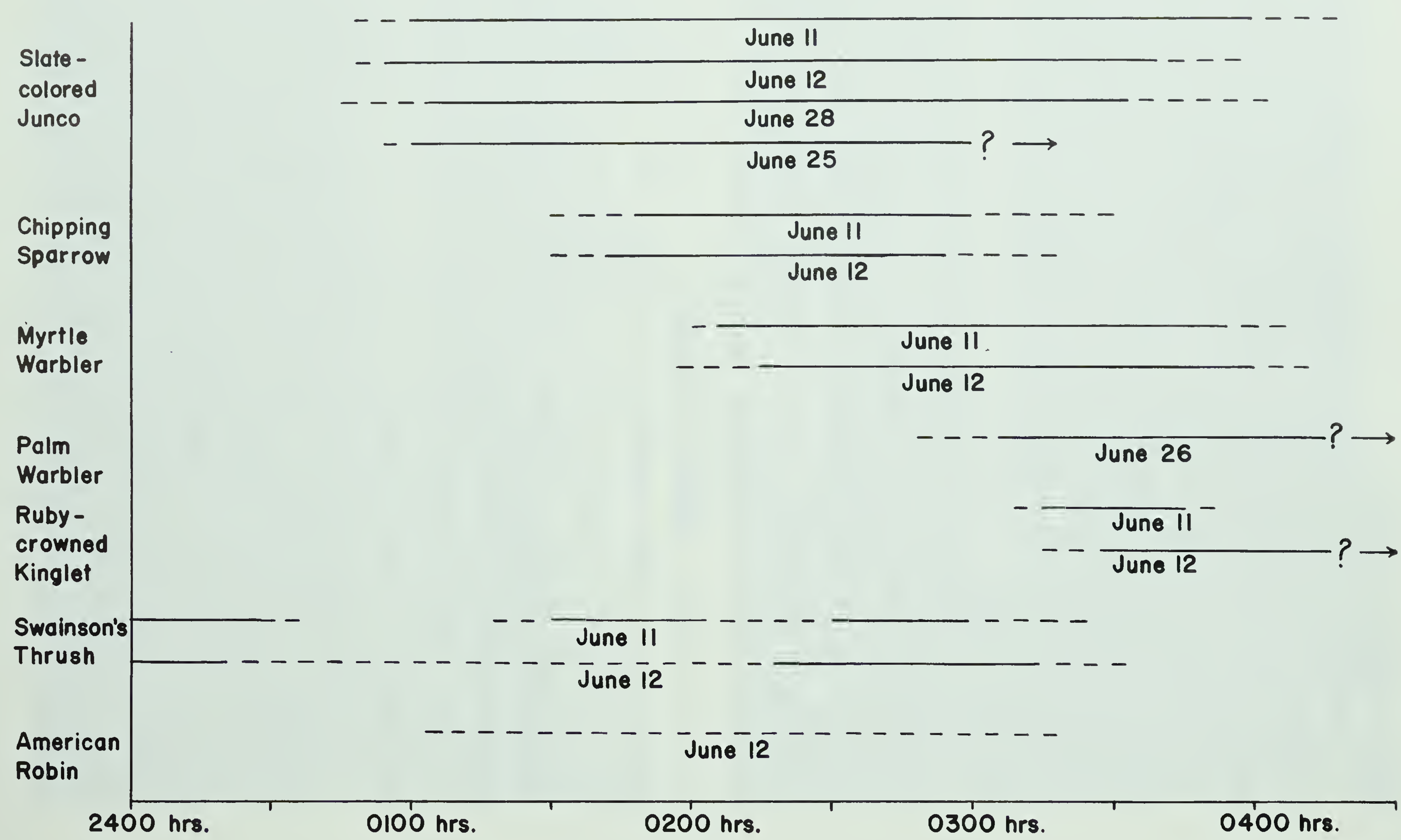
Figure 13. Zone B of Plot A, showing an open black spruce bog and post hole digger used in sampling permafrost levels.

Daily activity studies

Previous investigations have shown that the diurnal rhythm of non-colonial birds is not eliminated by longer photoperiods in arctic and subarctic regions (Palmgren, 1935, 1949; Marshall, 1938; Karplus, 1952; Armstrong, 1954; Brown, 1963; Remmert, 1964). The same phenomenon was observed in this study. Figure 14 shows the time of onset and duration of singing activity for seven different species that I investigated between 2400 and 0430 hours.

The first birds to commence singing near Rae (Lat. 62° 40'N) were Slate-colored Juncos at approximately 0100 hours, followed in close succession by Chipping Sparrows (*Spizella passerina* Oberholser), Myrtle Warblers (*Dendroica coronata* L.) and Palm Warblers (*Dendroica palmarum* Gmelin). The Ruby-crowned Kinglets (*Regulus calendula* L.) were the last of the passerines to begin singing on the days these investigations were conducted. Singing activity of Swainson's Thrushes (*Hylocichla ustulata* Tschudi) and Hermit Thrushes (*Hylocichla guttata* Bangs and Penard) generally decreased over this period of time. Evening songs, lasting well into the night, were pronounced in this species.

I found that the morning singing activity of other species declined by 0430 hours. Therefore, the period of maximum singing activity in the morning for most passerines was from 0100 to 0430 hours. I therefore concluded that the counts should be conducted between 0100 and 0430 hours, if the plots were to be sampled during the time of maximum activity. To determine if the singing intensities of the different species



Slate-colored Junco
June 11
June 12
June 28
June 25
Chipping Sparrow
June 11
June 12
Myrtle Warbler
June 11
June 12
Palm Warbler
June 26
Ruby-crowned Kinglet
June 11
June 12
Swainson's Thrush
June 11
June 12
American Robin
June 12
2400 hrs.
0100 hrs.
0200 hrs.
0300 hrs.
0400 hrs.

Figure 14. Onset and duration of early morning singing activity of seven common species. Solid line refers to regular recurring songs; broken line refers to period of irregular song or frequent calling.

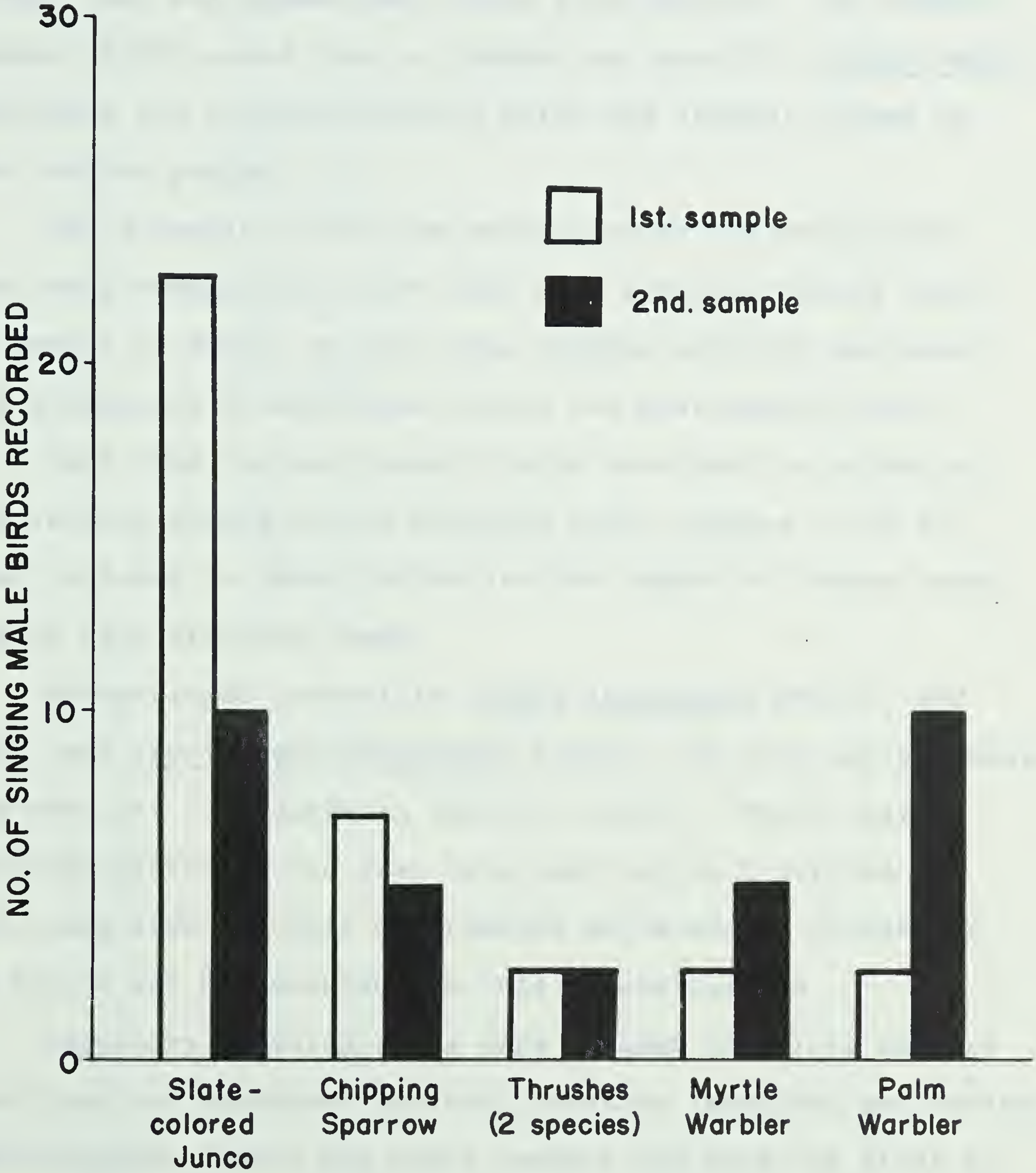
varied within this period I conducted two consecutive counts over the same transects.

On 25 June, 1965, I began the first count on Plot A at 0130 hours and the second count at 0340 hours (Fig. 15). The number of Swainson's, and Hermit thrush songs recorded remained fairly constant. This was also the case for the Chipping Sparrows. However, the number of warbler songs increased considerably during the second count. Myrtle and Palm Warbler songs increased by twice and five times that of the previous count. The number of junco songs recorded was considerably less on the second count. Therefore, even within the period of maximum activity the frequency of singing for different species varied. For this reason a time had to be chosen at which as many species as possible approached their period of maximum activity. I found that since each census lasted about 2 hours, a count that was begun at 0200 hours would encompass the optimum time for most species. To compensate for the differences in singing patterns, the starting points of the censuses were alternated (either point B or H in Figure 2).

Seasonal activity studies

The singing activity of different species of passerines varies within a season. Most migratory song birds sing irregularly during migration (Pettingill, 1961). Birds that are mute during migration begin singing shortly after arrival on their breeding grounds. Slate-colored Juncos, Gambel's Sparrows (*Zonotrichia leucophrys gambelii* Nuttal), Palm Warblers, Myrtle Warblers and Chipping Sparrows were observed singing

Figure 15. Number of singing male birds recorded during two consecutive counts on 25 June, 1965 on Plot A-I. The first sample count was conducted from 0130-0340 hours and the second from 0340-0530 hours.



30
20
10
0
NO. OF SINGING MALE BIRDS RECORDED
Ist. sample
2nd. sample
Slate-colored Junco
Chipping Sparrow
Thrushes (2 species)
Myrtle Warbler
Palm Warbler

sporadically during migration.

Singing may decrease in intensity or cease altogether during the short mating period and is resumed during nest building, egg-laying and incubation stages (Nice, 1937; Davis, 1958). Not all passerines follow this pattern. For example, Enemar (1959) notes that in Sweden the Great Tit (Parus major L.) decreased its singing activity after the initial stages of the nesting period.

While feeding young,the passerines on the study plots were very conspicuous since they were actively moving about in search of food. At this time singing activity decreased and subsequently terminated during the post-nuptial molt.

Data from the nest record cards were used to establish the various stages of the breeding cycle (Tables I and II). Also included in these tables are the number of counts taken during each breeding stage.

White-winged Crossbills (Loxia leucoptera Gmelin) and Gray Jays (Perisoreus canadensis Peters) are very early nesters and were not considered in Tables I and II. Their nesting activity generally had been completed before I arrived on the study area. A pair of breeding White-winged Crossbills on Plot B was an exception to this generalization.

Migratory breeding birds were divided into late nesters (warblers and thrushes) and early nesters (sparrows and robins). Slate-colored Juncos are early nesters and were the first to arrive on the breeding area. Arrival date at Rae in 1966 was 10 May. Stages of testicular increase in this species just prior to nesting are shown in Figure 16.

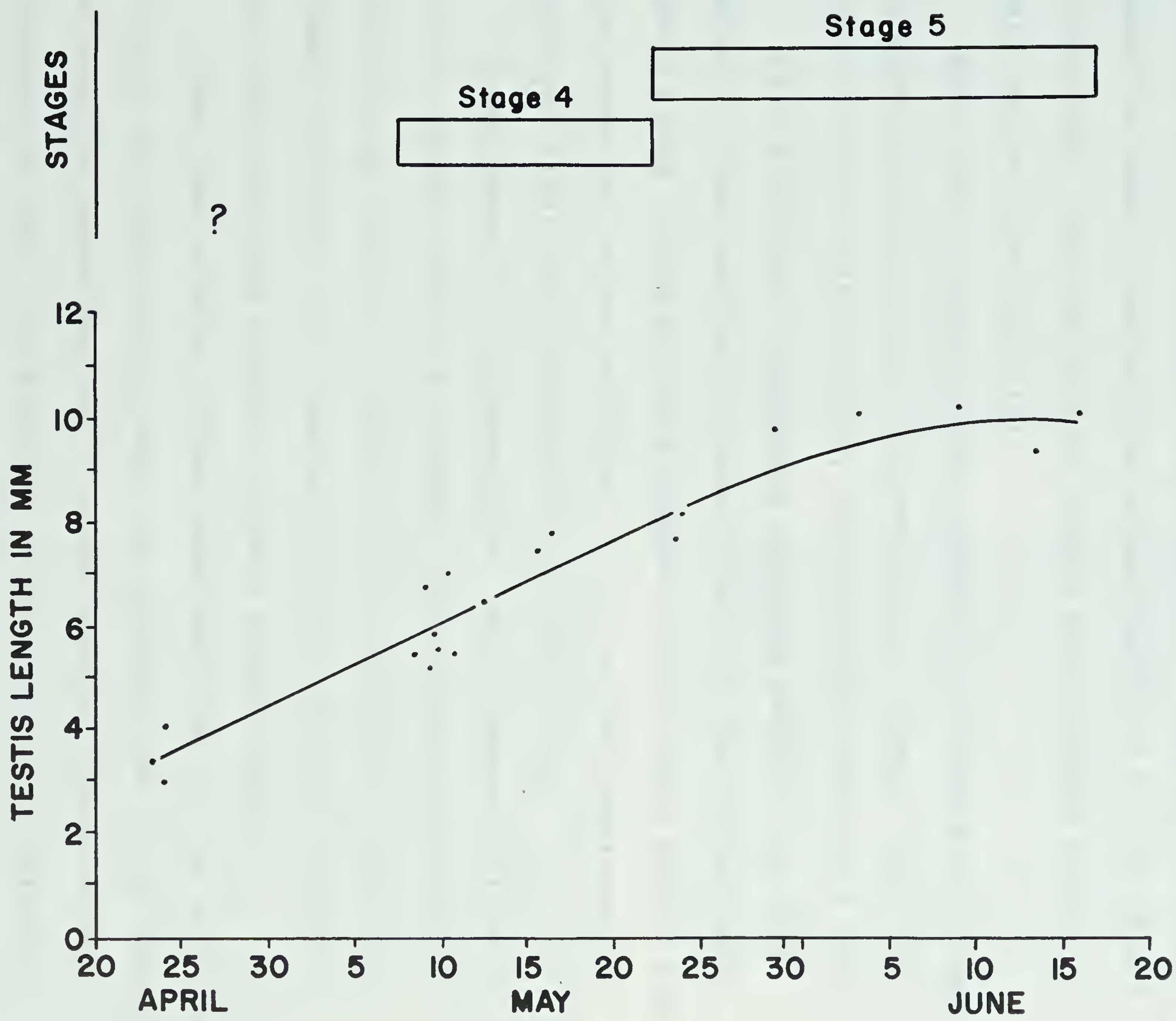
Table I. Number of counts taken on five plots at different stages of the breeding cycle of early nesting passerine species.

		Pre-nesting stage	Nest building stage	Egg laying stage	Incubation stage	Nestling stage	Post-nestling stage	
Year sampled	Plot	→May 26	May 27– May 30	May 31– June 4	June 5– June 17	June 18– June 27	June 28→	Total
1965	HL	-	-	1	6	-	1	8
1965	KL	-	-	-	6	1	-	7
1966	E	2	-	1	1	1	2	7
1966	B	2	-	-	2	1	2	7
1965	A-I	-	-	-	-	6	2	8
1966	A-II	1	-	1	3	-	2	7
1966	HL	-	-	-	-	-	4	4

Table II. Number of counts taken on the five plots at different stages of the breeding cycle of late nesting passerine species.

Year sampled	Plot	Pre-nesting stage →June 5	Nest building stage June 6–June 10	Egg laying stage June 11–June 15	Incubation stage June 16–June 27	Nestling stage June 28–July 7	Post-nestling stage July 8→	Total
1965	HL	-	6	-	-	2	-	8
1965	KL	-	1	4	1	-	1	7
1966	E	4	-	-	1	2	-	7
1966	B	2	2	-	1	1	1	7
1965	A-I	-	-	-	6	1	1	8
1966	A-II	2	1	1	1	2	-	7
1966	HL	-	-	-	-	3	1	4

Figure 16. Testicular development in Slate-colored Juncos during the early stages of the breeding cycle as determined by the length of the left testes and stages of spermatogenesis. The line of best fit was drawn by inspection.


STAGES
Stage 4
Stage 5
?
TESTIS LENGTH IN MM
0
2
4
6
8
10
12
20
25
30
5
10
15
20
25
30
5
10
15
20
APRIL
MAY
JUNE

Testes of migrating males collected at Yellowknife on 9 May were in stage 4 (Fig. 17). The first testes in stage 5 (Fig. 18) were collected on 19 May. This was the same day on which the first female was collected. Sizes of the left testes in stage 5 varied from approximately 7 x 4 to 10 x 7 millimeters. Maximum size of testes was attained by the beginning of June (Fig. 19).

Most Slate-colored Juncos seemed to be paired on 22 May, but nest-building was not observed until 28 May. The first female to show post-ovulatory follicles was taken on 4 June.

Yellow Warblers (Dendroica petechia Gmelin) are late nesters. These warblers, though absent on the plots, were common along rivers and lake shores. Of 21 nests found, six were destroyed before hatching. In 12 of the remaining 15 nests the first young hatched on 29 and 30 June.

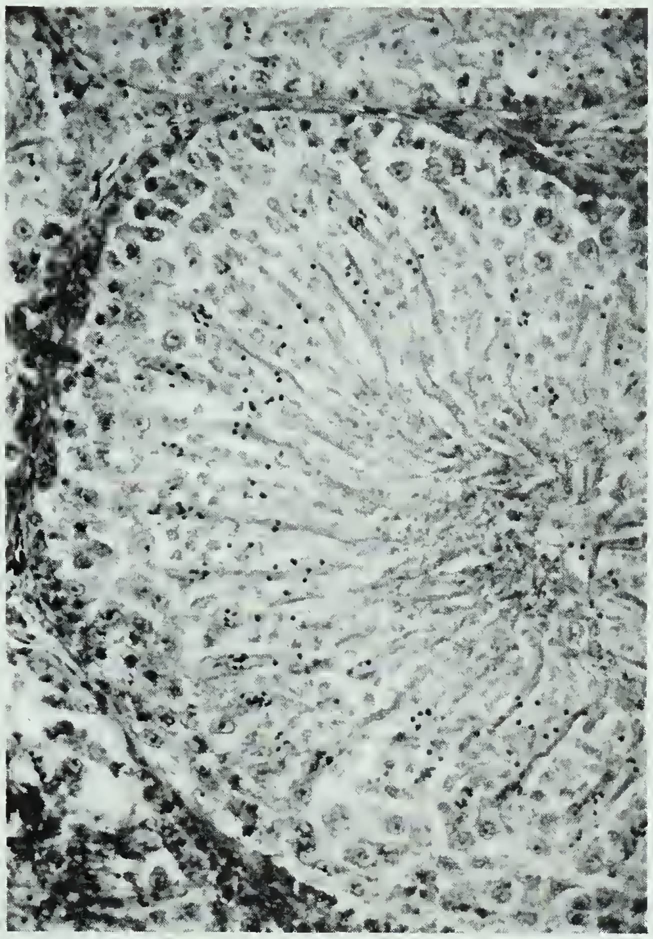
These dates for representative early nesters (Slate-colored Juncos) and late nesters (Yellow Warblers) follow the breeding stages of Tables I and II closely. They also compare favorably with seasonal breeding activity of the less numerous birds recorded on nest record cards.

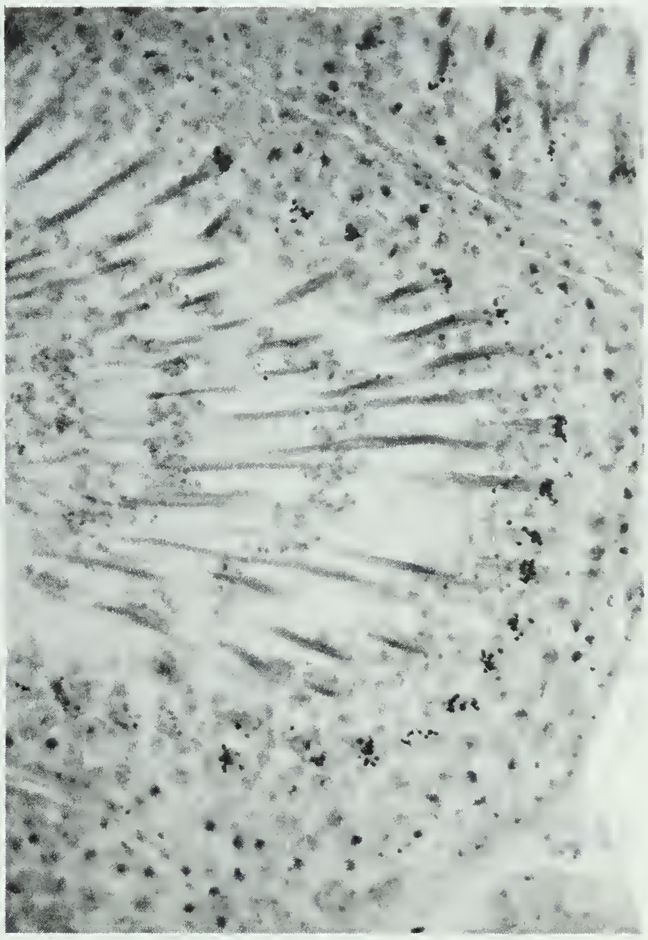
From these studies it was concluded that in the latitudes at which the counts were taken the optimum time in the season for sampling passerine birds in the breeding cycle is from 5 June to 27 June. This period extends from the beginning of the nest building stage of late nesters to the end of the nestling stage of early nesters.

Figure 17. Upper left. Cross-section of seminiferous tubule in stage 4 of a Slate-colored Junco collected 9 May, 1966 at Yellowknife, N.W.T. (Diameter of seminiferous tubule - app. 100 μ).

Figure 18. Upper right. Cross-section of seminiferous tubule in stage 5 of a Slate-colored Junco in full breeding condition, collected 14 June, 1966 at Rae, N.W.T. (Diameter of seminiferous tubule - app. 100 μ).

Figure 19. Lower photograph. Testes of a Slate-colored Junco *in situ* at maximum size of development, collected 31 May, 1966. (magnification - X3).





Census results

Table III shows the number of territorial passerine males of each species recorded on the plots. The order in which these birds are listed follows the American Ornithologists' Union check list (1957) fifth edition.

Members of the family Fringillidae were generally the most common birds present on the plots. This family was represented by five species. On all the study plots, except Plot HL, Slate-colored Juncos were the most numerous breeding birds. Chipping Sparrows were generally the second most common species. This species was not present on Plot E in 1966. Song Sparrows (*Melospiza melodia* Wilson) and Lincoln's Sparrows (*Melospiza lincolnii* Audubon) were uncommon. The single territorial White-winged Crossbill male present on Plot B was probably nesting on that plot. Individuals and small flocks of this species were frequently seen moving through the study areas, and may have represented resident birds that previously, or subsequently had nested in the area.

Myrtle Warblers were present on all the plots and were the most numerous breeding birds on Plot HL. Other warbler species encountered on the plots were Tennessee Warblers (*Vermivora peregrina* Wilson), Blackpoll Warblers (*Dendroica striata* Forster) and Palm Warblers. Tennessee Warblers were encountered on Plots HL and KL. Palm Warblers were present on Plots KL, E, A-I, and A-II. Blackpoll Warblers were rare and only one complete territory was recorded on Plot E.

Members of the thrush family (Turdidae) were present on all plots. However, only on Plot E were all four species of

thrushes sympatric. Two pairs of Gray-cheeked Thrushes were present on this plot. This species was absent on all other plots. The Hermit Thrush was also rare.

Species of the families Paridae, Tyrannidae and Bombycillidae were represented only by scattered breeding pairs. Ruby-crowned Kinglets (Sylviidae) were common in Zones A and D of Plot KL and appeared only sporadically on Plots HL and B.

The species of non-passerine and non-breeding passerine birds present on the plots are recorded in Table IV. These species did not seem to utilize exclusively the area within the plots. No data on the size of territories or home ranges were obtained. Possibly some of these birds were residents on the plots but were not regularly recorded because of their secretive habits. Other species, such as the very common Gray Jay, had completed their nesting activity before this study began. Mr. William McDonald of Yellowknife, N.W.T. has observed nest building and incubation of this passerine species as early as 24 March at ambient air temperatures of -38F. Gray Jays were extremely inquisitive and therefore they were attracted by my presence on the plots.

One nesting Mallard (*Anas platyrhynchos* L.), located on Plot A-II was approximately 1.5 miles from the nearest open water. Other bird species of particular interest in this table are the three diurnal and one nocturnal species of raptors — Sharp-shinned Hawk (*Accipiter striatus* Wilson), Marsh Hawk (*Circus cyaneus* L.), Sparrow Hawk (*Falco sparverius* L.) and Great-horned Owl (*Bubo virginianus* Gmelin).

Table III. Number of territorial passerine males on each of the 25-acre plots sampled. Fractions represent birds whose territories were only partially within the plot.

Species	Plot HL	Plot KL	Plot E	Plot B	Plot A-I	Plot A-II
Tyrannidae						
Traill's Flycatcher	-	1	-	-	-	-
Paridae						
Boreal Chickadee	-	1	-	1	-	-
Turdidae						
American Robin	2	1	1	1	-	-
Hermit Thrush	-	-	1	-	1	1
Swainson's Thrush	2.5	4	1	2	1	1
Gray-cheeked Thrush	-	-	2	-	-	-
Sylviidae						
Ruby-crowned Kinglet	0.5	6	-	1	-	-
Bombycillidae						
Bohemian Waxwing	2	-	1	-	-	-
Parulidae						
Tennessee Warbler	3	4	-	-	-	-
Myrtle Warbler	8	5	1.5	2.5	2	1
Blackpoll Warbler	-	-	1.5	-	-	-
Palm Warbler	-	0.5	2	-	5.5	3
Fringillidae						
White-winged Crossbill	-	-	-	1	-	-
Slate-colored Junco	4	9	4.5	6.5	11.5	11
Chipping Sparrow	7.5	7.5	-	3.5	3.5	2.5
Lincoln's Sparrow	-	3	-	-	-	-
Song Sparrow	-	-	-	-	1	-
Total	29.5	42	15.5	18.5	25.5	19.5

Table IV. Number of times that non-breeding passerines and non-passerines were recorded for each study plot. The figures in parentheses refer to the maximum number of encounters possible.

Species	Plot HL	Plot KL	Plot E	Plot B	Plot A-I	Plot A-II
Anatidae						
Mallard Duck	0(9)	0(7)	0(7)	0(7)	0(8)	7(7)-nesting
Accipitridae						
Sharp-shinned Hawk	1(9)	0(7)	0(7)	1(7)	1(8)	0(7)
Marsh Hawk	0(9)	0(7)	0(7)	0(7)	1(8)	0(7)
Falconidae						
Sparrow Hawk	0(9)	0(7)	1(7)	(7)	0(8)	1(7)
Tetraonidae						
Spruce Grouse	2(9)	3(7)	1(7)	1(7)	0(8)	0(7)
Scolopacidae						
Wilson's Snipe	0(9)	3(7)	1(7)	1(7)	0(8)	0(7)
Lesser Yellow-legs	0(9)	0(7)	0(7)	0(7)	3(8)	2(7)
Strigidae						
Great-horned Owl	1(9)	0(7)	0(7)	0(7)	0(8)	0(7)
Picidae						
Yellow-shafted Flicker	3(9)	1(7)	0(7)	4(7)	0(8)	0(7)
Northern Three-toed Woodpecker	0(9)	1(7)	0(7)	1(7)	0(8)	0(7)
Hirundinidae						
Tree Swallow	0(9)	0(7)	0(7)	1(7)	0(8)	0(7)
Corvidae						
Gray Jay	9(9)	7(7)	1(7)	7(7)	5(8)	4(7)
Fringillidae						
Pine Grosbeak	0(9)	1(7)	0(7)	0(7)	0(8)	0(7)
White-winged Crossbill	0(9)	0(7)	0(7)	0(7)	2(8)	1(7)

The number of Red Squirrels (Tamiasciurus hudsonicus Howell) recorded on each census is listed in Table V.

Table V. Red Squirrels present on the 25-acre plots.

	Plot HL	Plot KL	Plot E	Plot B	Plot A-I	Plot A-II
Maximum number seen during 1 count	1	2	0	1	2	2

There was no direct evidence of squirrel predation on either nests or young birds. However, the observed destruction of several passerine nests may have been the result of their activity.

Table VI summarizes, by species and plot, the biomass and numbers of breeding passerine birds on the basis of 100 acres. For all these calculations it was assumed that each singing male represented a pair of breeding birds. Therefore, the number of males recorded for each species on a 25 acre plot (Table III) was multiplied by eight to obtain the number of individuals of each species on a basis of 100 acres. Biomass figures were obtained by multiplying the number of individuals of each species by the average weight of each species. The weight averages were calculated from University of Alberta museum records (Appendix I). Whenever possible averages were based on 10 adult birds (5 males and 5 females).

Table VI. Number of individuals and biomass in grams of passerine birds recorded for the study plots, and calculated on a basis of 100 acres.

Species	Plot HL		Plot KL		Plot E		Plot B		Plot A-I		Plot A-II	
	No.	Bio-mass	No.	Bio-mass	No.	Bio-mass	No.	Bio-mass	No.	Bio-mass	No.	Bio-mass
Tyrannidae												
Traill's Flycatcher	-	-	8	96	-	-	-	-	-	-	-	-
Paridae												
Boreal Chickadee	-	-	8	88	-	-	8	88	-	-	-	-
Turdidae												
American Robin	16	1408	8	704	8	704	8	704	-	-	-	-
Hermit Thrush	-	-	-	-	8	240	-	-	8	240	8	240
Swainson's Thrush	20	620	32	992	8	248	16	496	8	248	8	248
Gray-cheeked Thrush	-	-	-	-	16	464	-	-	-	-	-	-
Sylviidae												
Ruby-crowned Kinglet	4	24	48	288	-	-	8	48	-	-	-	-
Bombycillidae												
Bohemian Waxwing	16	928	-	-	8	464	-	-	-	-	-	-
Parulidae												
Tennessee Warbler	24	216	32	288	-	-	-	-	-	-	-	-
Myrtle Warbler	64	768	40	480	12	144	20	240	16	192	8	96
Black-poll Warbler	-	-	-	-	12	144	-	-	-	-	-	-
Palm Warbler	-	-	4	40	16	160	-	-	44	440	24	240
Fringillidae												
White-winged Crossbill	-	-	-	-	-	-	8	200	-	-	-	-
Slate-colored Junco	32	608	72	1368	36	684	52	988	92	1748	88	1672
Chipping Sparrow	60	720	60	720	-	-	28	336	28	336	20	240
Lincoln's Sparrow	-	-	24	384	-	-	-	-	-	-	-	-
Song Sparrow	-	-	-	-	-	-	-	-	8	176	-	-
Total	236	5292	336	5448	124	3252	148	3100	204	3380	156	2736

Biomass relationships

The total biomass of breeding passerine birds varies considerably for the different plots. Plots KL and HL have the greatest biomass values. These plots also have the greatest diversity of plant cover (Figs. 3 and 4). Plots E and B have fairly uniform vegetation covers (Figs. 5 and 6), and the biomass values for these two plots are low.

For each plot, I have calculated the biomass values for the different families (Table VII). Also included in this table are the percentages that the biomass of each family contributes to total biomass. The family Fringillidae contributes most to the total avian biomass except on Plots E and HL where the biomass of the thrushes was greatest. Small populations of thrushes, because of their larger individual size, added significantly to the avian biomass. Warblers, though often numerically numerous, added less to the total biomass. The relationships between size of the populations and the biomass values for all the species on the plots are shown graphically in Figures 20 and 21.

Table VII. Biomass of birds in grams per 100 acres calculated for each family of passerines nesting on the study plots.

Family	Plot HL		Plot KL		Plot E		Plot B		Plot A-I		Plot A-II	
	Biomass	Percent	Biomass	Percent	Biomass	Percent	Biomass	Percent	Biomass	Percent	Biomass	Percent
Fringillidae (Graminivorous)	1328	25.1	2472	45.0	684	21.2	1524	49.2	2260	66.9	1912	69.8
Turdidae (Omnivorous)	2028	38.3	1696	31.0	1656	50.9	1200	38.7	488	14.4	488	17.8
Parulidae (Insectivorous)	984	18.5	808	15.0	448	13.7	240	7.7	632	18.7	336	12.4
Sylviidae (Insectivorous)	24	.5	288	5.0	-	-	48	1.5	-	-	-	-
Paridae (Insectivorous)	-	-	88	2.0	-	-	88	2.9	-	-	-	-
Bombycillidae (Omnivorous)	928	17.5	-	-	464	14.2	-	-	-	-	-	-
Tyrannidae (Insectivorous)	-	-	96	2.0	-	-	-	-	-	-	-	-
Total Biomass	5292		5448		3252		3100		3380		2736	

Figure 20. The relationship between numbers and biomass of breeding passerine birds present on the study plots. The number in the top of each bar refers to the number of individuals contributing to the total biomass of the particular species.

A. Upper graph, Plot HL
B. Middle graph, Plot KL
C. Lower graph, Plot E

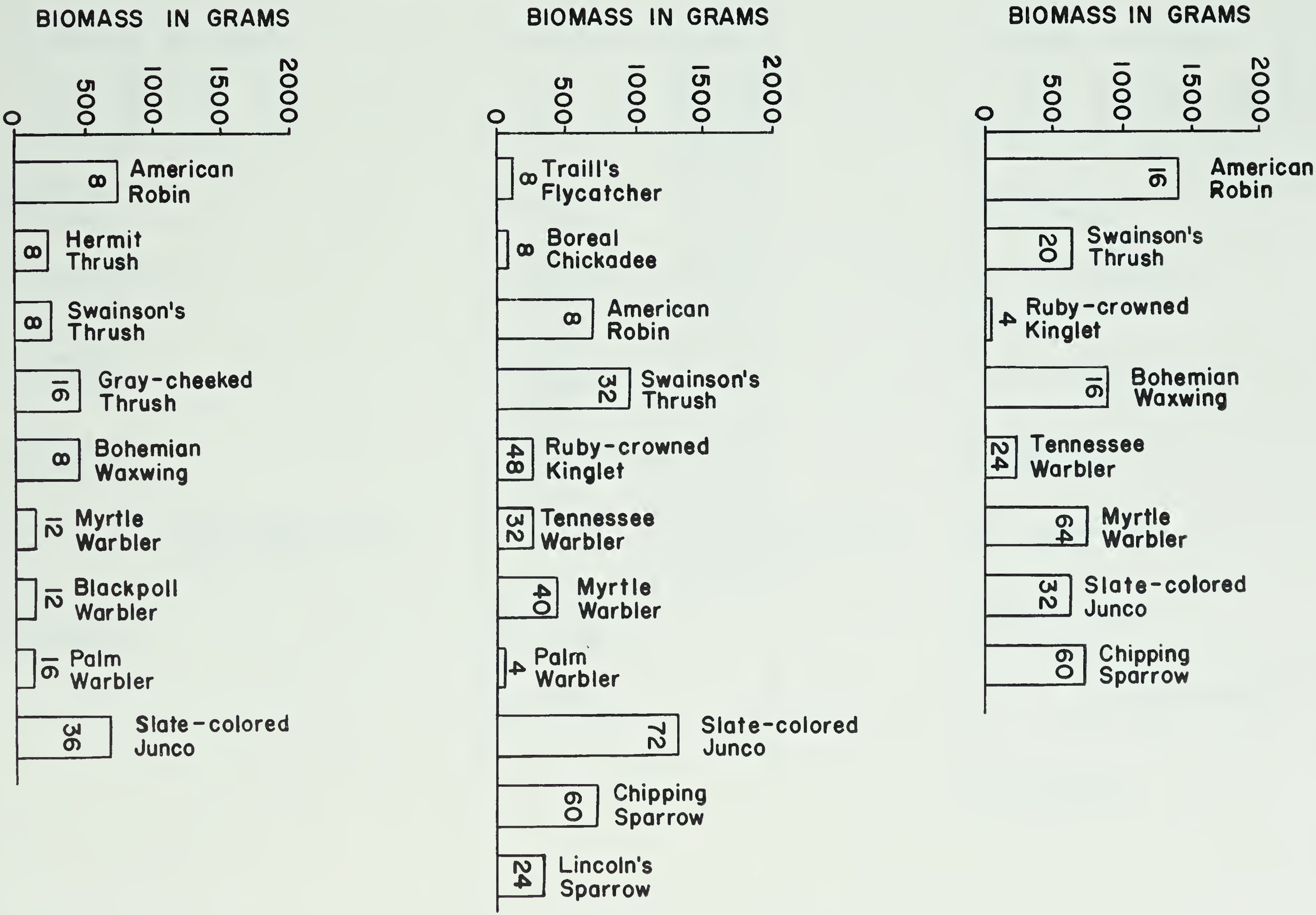
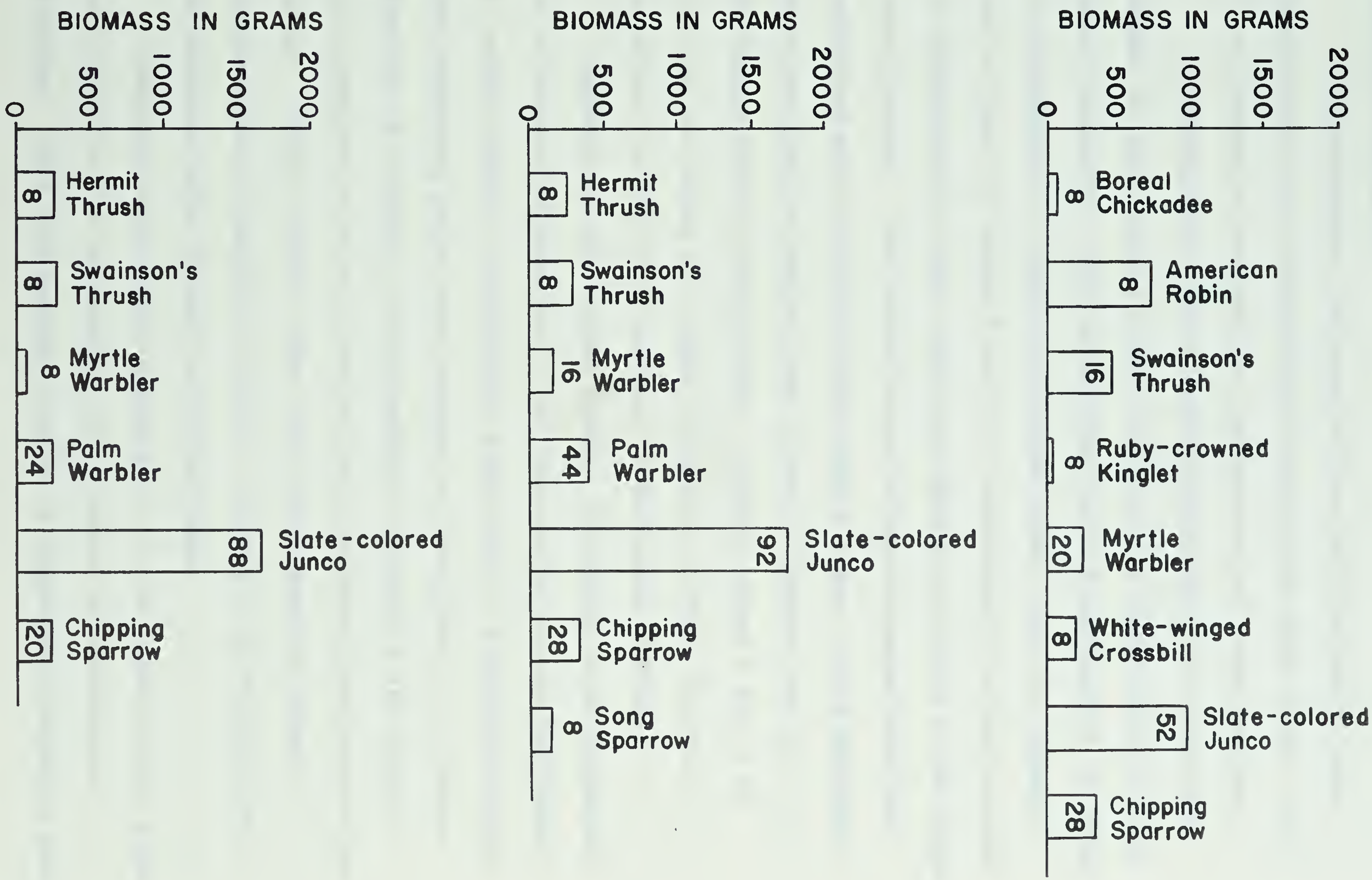

BIOMASS IN GRAMS
0
500
1000
1500
2000
8
American Robin
8
Hermit Thrush
8
Swainson's Thrush
16
Gray-cheeked Thrush
8
Bohemian Waxwing
12
Myrtle Warbler
12
Blackpoll Warbler
16
Palm Warbler
36
Slate-colored Junco
BIOMASS IN GRAMS
0
500
1000
1500
2000
8
Traill's Flycatcher
8
Boreal Chickadee
8
American Robin
32
Swainson's Thrush
48
Ruby-crowned Kinglet
32
Tennessee Warbler
40
Myrtle Warbler
4
Palm Warbler
72
Slate-colored Junco
60
Chipping Sparrow
24
Lincoln's Sparrow
BIOMASS IN GRAMS
0
500
1000
1500
2000
16
American Robin
20
Swainson's Thrush
4
Ruby-crowned Kinglet
16
Bohemian Waxwing
24
Tennessee Warbler
64
Myrtle Warbler
32
Slate-colored Junco
60
Chipping Sparrow

Figure 21. The relationship between numbers and biomass of breeding passerine birds present on the study plots. The number in the top of each bar refers to the number of individuals contributing to the total biomass of the particular species.

A. Upper graph, Plot B
B. Middle graph, Plot A-I
C. Lower graph, Plot A-II


BIOMASS IN GRAMS
0
500
1000
1500
2000
Hermit Thrush
8
Swainson's Thrush
8
Myrtle Warbler
8
Palm Warbler
24
Slate-colored Junco
88
Chipping Sparrow
20
BIOMASS IN GRAMS
0
500
1000
1500
2000
Hermit Thrush
8
Swainson's Thrush
8
Myrtle Warbler
16
Palm Warbler
44
Slate-colored Junco
92
Chipping Sparrow
28
Song Sparrow
8
BIOMASS IN GRAMS
0
500
1000
1500
2000
Boreal Chickadee
8
American Robin
8
Swainson's Thrush
16
Ruby-crowned Kinglet
8
Myrtle Warbler
20
White-winged Crossbill
8
Slate-colored Junco
52
Chipping Sparrow
28

Habitat selection

I superimposed the maps of the territories of each species over the corresponding vegetation maps (Figs. 3 to 7) to determine the habitat preferences of each species.

Slate-colored Juncos and Chipping Sparrows were most common in open spruce bogs, but were not restricted to this plant community. Myrtle Warblers were found mainly in areas of predominantly large coniferous trees (Plot HL, Zones B and C; Plot KL, Zones A and D). Occasionally a pair nested in predominantly open vegetation areas with only a few larger trees present. The distribution of Ruby-crowned Kinglets coincided with stands of tall spruce trees. Palm Warblers were confined to spruce bogs (Plot A, Zones B and C). A deciduous tree or shrub cover, notably Zones B and D of Plot HL and along the edges of Zone C of Plot KL, was important in the distribution of Tennessee Warblers.

Members of the thrush family (Turdidae) were dispersed in a variety of habitats. For this group it was difficult to assign habitat preferences since only a few wide ranging and scattered pairs were present on the plots. All three species of thrushes, Gray-cheeked, Swainson's and Hermit, were present on Plot E, which had a uniform black spruce tree cover. Dilger (1956) found that these species showed differences in feeding "niches", in height of foraging and in location with respect to forest-edge.

Factors determining dispersion of the birds on the plots would have to be determined by intensive autecological studies. Only the general trends in dispersion patterns have

been recorded here.

The dispersion of the populations on Plot KL is particularly interesting since this plot had a diverse plant cover. I analysed the distribution patterns of the populations on the plot by applying the nearest neighbor test (Clark and Evans, 1954). The formulae used are listed in Appendix II.

For these calculations the geometrical centers of the territories as they appear on the composite maps were used as reference points to measure the distances between nearest neighbors. Since the exact boundaries of the territories are not known this method is not completely accurate. A better measure would be the distance between nests. Nevertheless, the distance to nearest neighbor test is useful if its limitations are realized.

In each community the dispersion of species with four or more territorial males was uniform; but the distribution of that species tended to be less uniform if the total population of the species for the whole plot was considered.

For example, the mean distances between nearest neighbors of five Slate-colored Junco males in a 9.5 acre spruce-bog community (Zone B, Fig. 4) was 190 feet. By the nearest neighbor method the theoretical mean distance for an infinitely large and random population of this density was calculated to be 147 feet. When the actual mean from map measurements was divided by the theoretical mean an index of departure from randomness (R) of 1.29 was obtained. This indicates a trend from randomness toward uniformity since an index of 1.00 is characteristic of a random distribution and

a maximum uniformly spaced population has an index of 2.149.

The R value calculated for the total Junco population on the whole plot is 1.1. Hence the distribution of the Slate-colored Junco on Plot KL is less uniform and much closer to randomness than within the single Zone B.

Similarly, the distribution of Myrtle Warblers and Ruby-crowned Kinglets tended to be uniform within a given community, but was less uniform when the total population on the plot was considered. This can be explained by the heterogeneous nature of the plant cover. Communities that are generally "unsuitable" for a species may provide sufficient cover to support one breeding pair. This would result in a more random distribution of the total population within the plot.

The distribution of the two most common fringillid species, Slate-colored Juncos and Chipping Sparrows, frequently overlapped. To test this over-lap in distribution of the two species statistically, I analysed the number of quadrats on which these birds occurred on the Plots HL, KL, A-I, and B. For each quadrat on these plots one of the four following possibilities exists: both species are absent, both species are present, Slate-colored Juncos are present and Chipping Sparrows are absent, or Chipping Sparrows are present but Slate-colored Juncos are absent. The frequency of occurrences of these four possibilities on the quadrats for each plot is tabulated in Table VIII.

Table VIII. Distributional relationships of Slate-colored Juncos and Chipping Sparrows on Plots HL, KL, A-I, and B.

	Species B Chipping Sparrows	Species A Slate-colored Juncos Present	Species A Slate-colored Juncos Absent
Plot HL			
	Present	12	18
	Absent	14	20
Plot KL			
	Present	17	11
	Absent	10	26
Plot A-I			
	Present	19	4
	Absent	19	22
Plot B			
	Present	11	4
	Absent	12	37

By applying a modified Chi-square test to the data of Table VIII (Southwood, 1966) a preference for the same habitat in these two species was tested statistically. The results are significant at the 5 per cent level for Plots KL, A-I and B, but not for Plot HL. The formula for the modified Chi-square test is listed in Appendix II.

Because the values were significant for three plots, further testing was carried out by applying to the data in Table VIII , the formula for the coefficient of interspecific association (Appendix II). Cole (1949) points out that for this formula, coefficient values range from +1 (complete positive association) to 0 (no association) to -1 (complete negative association). The values obtained were .320±.118 (Plot KL), .571±.200 (Plot A-I) and .588±.167 (Plot B).

Therefore, the two species show a positive association in the habitats of these three plots.

This was not the case for all plots. A few Slate-colored Juncos, but no Chipping Sparrows, nested on Plot E. Chipping Sparrows were common on plot HL but the habitat association of this species with the few Slate-colored Juncos was not significant at the 5 per cent level when a Chi-square test was applied to the data. Therefore, in the areas sampled, the Chipping Sparrows and Slate-colored Juncos often showed a strong common habitat preference; however the two species were not invariably found in the same habitats.

In order to compare the total populations of all species on the different plots, I calculated the indices of diversity and the indices of similarity of these populations. Because the plots contain several plant communities, the indices are not indicative of the diversity and similarity of populations on plots with homogeneous plant cover.

Index of similarity

In the following calculations twice the sum of the least number of individuals of all species common to two plots is divided by the total number of birds present on the two plots to obtain the index of similarity values (Bond, 1957). Only the passerines listed in Table III were used in these calculations.

Formula: $$\text{I.S.} = \frac{2\sum W}{A + B}$$ where

$\sum W$ = least number of individuals of all species occurring on both plots

A = sum of all the birds on one plot

B = sum of all the birds on the second plot

The index ranges from 0 to 1; a value of 1 would express complete similarity of the avifauna on the two plots compared. The results of these calculations for all the plots are listed in Table IX.

Table IX. Indices of similarity between the various 25 acre plots based on the species and number of individuals of breeding passerines.

Plots	HL	KL	E	B	A-I	A-II
HL	-	-	-	-	-	-
KL	0.65	-	-	-	-	-
E	0.36	0.28	-	-	-	-
B	0.56	0.57	0.44	-	-	-
A-I	0.40	0.48	0.49	0.62	-	-
A-II	0.36	0.45	0.50	0.51	0.91	-

The populations of Plots A-I and A-II have the highest index of similarity value (0.91). This can be expected since the populations were from an area sampled in two consecutive years. Plots KL and E have the lowest index of similarity value (0.28). This low index was due probably to their difference in degree of variation in the plant cover. Compared to the other plots,

the plant cover of Plot KL (Fig. 4) was most varied, and the plant cover of Plot E (Fig. 5) was most uniform.

Species diversity

Species diversity can be expressed in a number of ways. Several methods are described below.

A simple method is to record the number of species present in an area. This was done for each plot (Table X). This table was derived from Tables III and IV.

Table X. Number of breeding, non-breeding passerines and non-passerine species recorded on each plot.

Plot	Breeding passerine species	Non-breeding passerine and non-passerine species	Total no. of species
HL	8	5	13
KL	11	6	17
E	9	4	13
B	8	8	16
A-I	7	5	12
A-II	6	5	11

A second way used to describe the species diversity is to set up density classes. This method describes the diversity of the plots on a quantitative basis (Udvardy, 1957). The density classes are 50-41, 40-31, 30-21, 20-11, 10-6 and fewer than 6 singing males per 100 acres. The number of territorial passerine species in each density class expressed as males per 100 acres is listed in Table XI.

This Table shows that the majority of the species on the plots are in the lower density classes.

Table XI. Number of breeding passerine species in each density class expressed as males per 100 acres for each plot.

	Density classes						
	50-41	40-31	30-21	20-11	10-6	<6	Total
Plot HL	-	1	1	2	3	1	8
Plot KL	-	1	2	4	-	4	11
Plot E	-	-	-	1	4	4	9
Plot B	-	-	1	1	2	4	8
Plot A-I	1	-	1	1	1	3	7
Plot A-II	1	-	-	1	1	3	6

In Table XII the species diversity is again presented quantitatively. This table is an expansion of Table XI. The numbers of breeding pairs of the species listed in each density class of Table XI are totalled and tabulated in Table XII.

Table XII. Total number of pairs of breeding passerines of each density class, expressed as males per 100 acres for each plot.

	Density classes						
	50-41	40-31	30-21	20-11	10-6	<6	Total
Plot HL	-	32	30	28	26	2	118
Plot KL	-	36	54	64	-	14	168
Plot E	-	-	-	18	28	16	62
Plot B	-	-	26	14	18	16	74
Plot A-I	46	-	22	14	8	12	102
Plot A-II	44	-	-	12	10	12	78

A more precise method of recording species diversity of an area was formulated by MacArthur and MacArthur (1961). This index includes the number of species and the number of individuals (density) of each species in an area.

For each species the following was calculated:

$$- p_i \log_e p_i$$

where pi is the proportion of the singing males of a species to the total singing male population on the plot. For each species this value was calculated and totalled to obtain the indices tabulated in Table XIII.

Table XIII. Species diversity indices as calculated from MacArthur's formula.

	Plot HL	Plot KL	Plot E	Plot B	Plot A-I	Plot A-II
Species diversity	1.861	2.063	2.018	1.748	1.562	1.316

According to this method Plot KL has the highest index of species diversity, followed by plots E, HL, B, A-I and A-II, respectively. This method ranks the plots in the approximate same order of species diversity as is obtained when the diversity values of the plots are determined from the number of species on each plot. However, the total number of species present in a given area is often an inaccurate criterion of species diversity, because it does not distinguish between common and rare species. Therefore, I used MacArthur's formula to calculate an index of species diversity that included both the number of species and the number of individuals of each species.

The indices of similarity were calculated so that the plots could be arranged according to their avifaunal affinities. Communities with high or low indices of diversity do not necessarily show a high degree of similarity. The index of similarity takes into account the species common to both plots, whereas the index of diversity indirectly evaluates the quality of the habitat in terms of the numbers and species present. A good example of this difference is illustrated by

[illegible]

[illegible]

[illegible]

Plots KL and E. Both plots have high indices of diversity but when compared to each other, they have a low index of similarity. Therefore, in comparing populations, on the basis of these indices, it is not sufficient to draw conclusions solely from the magnitude of the indices.

Zoogeographical analysis

Appendix III lists the birds occurring at Rae and Yellowknife, N.W.T., the northernmost section of the Great Slave Lake Highway. Mayr (1946) was consulted for the probable origins of the families of these species.

The categories Old World, South American, and North American have been assigned by Mayr to families whose probable origins can be established from their current distributions. The tracing of the origin of families with a wide distribution is often difficult. Birds in this category have been assigned to an "unanalysed category".

In this analysis only the common breeding birds (CB) and resident (Res) birds were considered. It was found that of the 89 more common species, 50 per cent were of the unanalysed element, 23 per cent of North American, 18 per cent of Old World and 9 per cent of South American origin. Furthermore, when the origins of the resident species are considered, then 50 per cent are of an Old World origin, 30 per cent belong to the unanalysed element and 20 per cent are of North American origin. These analyses support the general statement made by Mayr (1946) that the avifauna of northern forests has a high percentage of Old World species and a small South American element.

In each case the origin of the species is considered in the context of the origin of the families, to which the species belong. It is therefore not correct to imply that the percentages apply to the origin of the species as such, but it does indicate the ancestral affinities of the avifauna of the region.

When the species of the common breeding and resident birds of the unanalysed element are considered separately, then 49 per cent are holarctic and 51 per cent are strictly North American in distribution. This would suggest that a large percentage of the species in the unanalysed category originated in North America.

By comparing my records of bird distribution in the western region of Great Slave Lake with distribution maps of Godfrey (1966), the ranges of the following bird species were extended: Ring-necked Duck (*Aythya collaris* Donovan), Pileated Woodpecker (*Dryocopus pileatus* Bangs), Hermit Thrush, Common Starling (*Sturnus vulgaris* L.), Black-throated Green Warbler (*Dendroica virens* Gmelin), Golden-crowned Kinglet (*Regulus satrapa* Lichtenstein), Harlequin Duck (*Histrionicus histrionicus* L.), and Black-capped Chickadee (*Parus atricapillus* Harris). The last two species were recorded near Yellowknife by Mr. William McDonald.

DISCUSSION

The precision and accuracy of a census method governs the value of the data collected. The precision refers to the repeatability of the measurements. Therefore, the precision depends on the singing activity of the males, and on the performance of the observer. Accuracy of a census refers to the constant relationship of the actual number of birds present on plots to the number that was determined by the method used. In the Williams Spot-mapping technique, the lack of precision of the early morning counts lowers the accuracy of the census.

Seasonal and daily timing are important in the precision of a count. Stages within the gonadal cycle probably control the daily activity pattern of males to a large extent. Davis (1958) found a direct correlation between increase in earliness and maximum intensity of the song of Rufous-sided Towhees (Pipilo erythrophthalmus Swainson) as the males reached the full breeding condition. Enemar (1959) found that in southern Sweden (approximate latitude 56°N) singing activity in passerines during the breeding season continued throughout the day. However, he mentions that the intensity of song decreases from early morning to the afternoon. I found that after 0430 the intensity of singing by all species dropped significantly at latitudes 61°-63°N. In Abisko, Swedish Lapland (latitude 68°N) Armstrong (1954) found that the period of maximum singing activity for most passerines was also between midnight and 0430 hours. Similar results are

recorded by Weeden (1965) for Tree Sparrows (Spizella aborea Brewster) in Alaska (latitude 65°N).

Changes in the singing activity of birds are directly related to the stages in the breeding cycle (Nice, 1937; Enemar, 1959; Welty, 1962). Generally the singing activity is greatest at the onset of territorial activity, and ceases altogether during the postnuptial molt. Because of the short summer, the breeding season of the migratory birds on my study area was telescoped into a brief period. This tended to force the breeding stages of the various species to coincide. There was no evidence of two broods raised. If the shifting of breeding stages resulting from nest destruction and predation is disregarded, then the optimum time to conduct counts is from 5 June to 27 June. Counts taken before 5 June would record a large percentage of migrants and birds that have not established territories, whereas any counting of birds after 27 June would include shifting bird populations that have completed their nesting in other areas. Saunders (1948) and Mehner (1952) have found that the average cessation dates of seasonal singing activity varied from year to year. In the boreal forest, the onset of nesting activity of passerines is probably directly related to the environmental conditions in spring. Thus, the optimum time to conduct the counts can be expected to vary from year to year depending on a late or early spring.

Other factors that affect the precision of the counts are weather conditions and walking speed along census lines. Rain, high winds and extremes in temperature lower the

intensity and duration of singing (Scheer, 1952; Armstrong, 1954; Welty, 1962). In this study counts were carried out only on calm, clear or partially overcast days. A slow walking speed would compensate for a decrease in intensity of bird song under adverse weather conditions. However, I maintained a fairly constant rate of 50 ft per minute, regardless of small changes in environmental conditions.

The accuracy of the census depends in part on the precision of each individual count and in part on the various possible sources of error. An obvious source of error using the Williams Spot-mapping method is equating one singing male to one breeding pair of birds, because unmated males often defend territories. Males without mates amounted to 9 per cent of a House wren (Troglodytes aedon Audubon) population (Kendeigh, 1944), 16 per cent in a Song Sparrow population (Nice, 1937) and unmated males were reported for an insular Song Sparrow population by Tompa (1964).

Polygyny has been observed in 14 of 291 species of North American passerines (Verner and Willson, 1966). However, most of the polygynous species were breeding in areas of abundant food supply such as marshes. Because of the low densities of birds in this study, it is unlikely that any of the passerines were polygynous. Furthermore, none of the species that were reported as polygynous were encountered on the plots.

Delineating territories on composite maps is another source of error, because the records of singing locations are often spread evenly over a considerable area. The problem was

partly overcome by marking on the field maps the locations of the males that were singing simultaneously. A certain amount of subjectivity was unavoidable. I believe that in areas of high densities the actual number of territories may be overestimated. For example, Slate-colored Juncos in open spruce bogs were very common, and the extensive movement of one male could have resulted in the recording of two territories for the one individual.

Species differ in conspicuousness and degree of territoriality. The breeding status of some birds that were recorded only once or twice, such as Boreal Chickadees (Parus hudsonicus Rhoads.) was often doubtful.

Competition, predation and nest destruction may cause mid-season shifting of territories (Hall, 1964). Errors due to this factor are minimized if counts on each plot are taken on at least three consecutive mornings and not spread over the whole season. The counts on Plot A in 1966 were more widely spaced, and this may partially account for its lower population density in comparison to the values obtained in 1965 for Plot A.

One hundred acres is a standard used by most North American and British investigators. The size of the plots is significant in obtaining reliable results, especially when these are converted to a basis of 100 acres. For example, the small difference in the number of singing males on Plot A from one year to another was magnified when converted to a total number of birds per 100 acres. Another disadvantage of small plots is that the perimeter to area ratio is

proportionately greater than on larger plots. A greater percentage of territories will be, therefore, partly within and partly outside the plot. Plots must be large enough to include the activity of most of the birds breeding in the area. A disadvantage of very large plots (greater than 50 acres) is that the morning activity may decline before the count on the plot is completed.

From the above discussion it is evident that many factors influence the accuracy of a census. Three experimental methods can be used for checking the accuracy of the census. These are (a) capturing and banding the total population (Nice, 1937; Tompa, 1964), (b) intensive repeated observations of a few marked birds in a small area (Odum and Kuenzler, 1955), and (c) conducting "shoot outs" (Stewart and Aldrich, 1951). However, the first two methods are time consuming and best carried out in areas with well defined boundaries (islands, isolated woodlots and valleys). Shoot outs usually do not account for all the birds present on the plots.

Passerine breeding populations on the plots in my study area varied from 62 pairs (Plot E) to 168 pairs (Plot KL) per 100 acres. Stewart (1955) was the only other investigator to conduct a comparable study in the Great Slave Lake region. His plots were located along the Little Buffalo River within Wood Buffalo National Park. Passerine breeding bird populations in this area averaged 207 and 131 pairs per 100 acres in lowland and upland white spruce forests respectively. Avifaunal investigations in a tundra region of northwestern Alaska resulted in breeding bird densities ranging from a low

of 24 pairs to 194 pairs per 100 acres (Williamson, Thompson and Hines, 1966). These figures include a large percentage of non-passerine birds. Stewart and Aldrich (1952) recorded 320 to 415 pairs of passerines per 100 acres in a Spruce Budworm infested coniferous forest of Maine. Similarly, Kendeigh (1947) recorded 319 pairs of passerines per 100 acres in a mixed coniferous forest during a budworm outbreak in Ontario. Avian populations during these insect infestations were abnormally high (Stewart and Aldrich, 1952). Snyder (1950) working in Colorado recorded a density of 102, 87 and 54 breeding pairs of passerines per 100 acres in montane, subalpine and lodgepole pine (Pinus contorta Loudon) forests respectively. Breeding bird populations in Finish forests compared favorably with my results; Palmgren recorded 81 pairs per 100 acres and Soveri recorded 94 pairs per 100 acres (Snyder, 1950). Included in these figures by European workers are also the non-passerine breeding birds.

The differences in results can be explained by (1) the different census methods used; (2) geographical location of the areas; (3) different successional stages of the plant communities; (4) time and effort spent in the field by the investigator. For these reasons, one has to be cautious in generalizing from data that were obtained from various sources.

Most workers have expressed the populations as individuals per 100 acres or per 100 hectares. Turček (1956) and Salt (1957) converted the population figures to biomass values for different plant communities in coniferous forests. Salt (1957) obtained biomass figures for passerines ranging from

977 grams per 100 acres in lodgepole pine areas to 7424 grams per 100 acres for willow-sedge swamps of Wyoming. In my study areas the biomass values ranged from 2736 grams per 100 acres to 5486 grams per 100 acres on the different plots. For the Slovakian Spruce forest community, Turček (1956) reported a biomass value of approximately 19,300 grams per 100 acres.

More detailed studies are necessary to understand the significance of biomass differences and its importance to energy transfers in the ecosystem. In my survey the graminivores and the omnivores contributed the highest percentages to the avian biomass. Similar results were obtained by Salt (1957) for coniferous forests, however, he reports that the reverse relationship exists in deciduous forests.

The feeding habits of birds were not studied in detail and the general groupings, graminivores, omnivores and insectivores were chosen after Turček (1956), Salt (1957), and Lack (1966). It is probable that the food habits of the different birds change seasonally (Welty, 1962). A high percentage of the birds categorized as omnivorous and graminivorous in this study probably feed to a large extent on insects during the summer months. For example, an examination of 10 Slate-colored Junco gizzards in June yielded considerable amounts of insect material in the form of finely divided exoskeletons.

Availability of food supply is one of the many factors that can be expected to determine the distribution of birds

in different habitats, and in different strata of the vegetation. In a general study, it is difficult to obtain detailed information on the exact factors that determine the distribution of the different species. Kendeigh (1945) refers to this difficulty when he states that "In analyzing the factors involved in community selection by birds, the difficulty is experienced that much of the evidence is intangible, obscure, and inferential, and not subject to experimental proof at the present time." Hildén (1965) has described some of these factors in detail. In this study only the obvious habitat preferences have been considered.

Slate-colored Juncos and Chipping Sparrows showed the widest distribution. Often areas that seemed "suitable" for these species were not utilized. It is unlikely that the areas of low junco densities acted as marginal habitats absorbing surplus birds from high density areas as described by Kluyver and Tinbergen (1953) for European titmice. Their hypothesis implies that densities in the favorable habitats will increase until the attractiveness of the habitat is counter balanced by the repelling influence of the population already present. Similar observations were made by Tompa (1962, 1964). He found that the density of Song Sparrow populations was controlled by their territorial behavior. It is possible that in northern latitudes other limiting factors, such as food, high mortality during migration, short nesting season, limited suitable wintering areas, will control population levels before territorial behavior and available

space set the upper population density limits.

The number of bird species in northern latitudes is less than in more southerly latitudes, (Udvardy, 1957; Pianka, 1966). This fact has given rise to speculation on the factors determining species diversity at different latitudes. Results which I have used to determine species diversity on the different plots could be compared with results from avian studies on similar plots in tropical areas. So far ecological data that could be used for comparative purposes is scant (Pianka, 1966).

For future investigations, I would suggest two approaches, 1) intensive studies on a 25 acre plot with a diverse plant structure, and 2) extensive sampling of all the major habitats by using a method of absolute census on transects. The intensive study should include (a) detailed study of the structural features of the vegetation, (b) record the territories of all the males on the plot by applying Williams Spot-mapping method and supplementing these results with repeated observation on marked birds, (c) locate all the nests, (d) study the feeding habits of birds by collecting stomach samples throughout the spring and summer.

Once the population dynamics and the activity patterns of the birds have been thoroughly investigated on a small area, extensive surveys could be undertaken to include the populations of migratory birds in a variety of habitats.

LITERATURE CITED

American Ornithologists' Union. 1957. Check-list of North American birds. 5th ed. Lord Baltimore Press. Baltimore, Md. 691 p.

Armstrong, E. A. 1954. The behaviour of birds in continuous daylight. Ibis, 96:1-30.

Atlas of Canada. 1957. Dept. of Mines and Technical Surveys, Queen's Printer, Ottawa.

Blanchard, B. D. 1941. The White-crowned Sparrows (Zonotrichia leucophrys) of the Pacific Seaboard: environment and annual cycle. Univ. of Calif. Publ. Zool., 46:1-177.

Bond, R. R. 1957. Ecological distribution of breeding birds in the upland forests of southern Wisconsin. Ecol. Monog., 27:351-384.

Brown, R. G. B. 1963. The behaviour of the Willow Warbler (Phylloscopus trochillus) in continuous daylight. Ibis, 105:63-75.

Clark, P. J., and F. C. Evans. 1954. Distance to nearest neighbor as a measure of spatial relationships in populations. Ecology, 35:445-453.

Cole, L. C. 1949. The measurement of inter-specific association. Ecology, 30:411-424.

Colquhoun, M. K. 1940. Visual and auditory conspicuousness in woodland bird community: a quantitative analysis. Proc. Zool. Soc. London, 110:129-148.

Daubenmire, R. F. 1938. Merrian's life zones of North America. Quart. Rev. Biol., 13:327-332.

Davis, J. 1958. Singing behaviour and the gonad cycle of the Rufous-sided Towhee. Condor, 60:308-336.

Dice, L. R. 1930. Methods of indicating relative abundance of birds. Auk, 47:22-24.

__________ 1943. The biotic provinces of North America. Univ. of Michigan Press, Ann Arbor. 78 p.

Dilger, W. C. 1956. Adaptive modifications and ecological isolating mechanisms in the thrush genera Catharus and Hylocichla. Wilson Bull., 68:171-199.

Dowden, P. B., H. A. Jaynes, and V. M. Carolin. 1953. The role of birds in a spruce budworm outbreak in Maine. J. Econ. Entomol., 46:307-312.

Elton, C. S., and R. S. Miller. 1954. The ecological survey of animal communities: with a practical system of classifying habitats by structural characters. J. Ecol., 42:460-496.

Enemar, A. 1959. On the determination of the size and composition of a passerine bird population during the breeding season. Vår Fågelvärld, Suppl. 2. 114 p.

__________ 1963. The density of birds in the subalpine birch forest of the Abisko Area Swedish Lapland, in 1961. Lunds Univ. Årsskrift, 58:1-21.

Godfrey, W. E. 1966. The birds of Canada. Queen's Printer, Ottawa. 428 p.

Hall, G. A. 1964. Breeding bird census -- why and how. Aud. Field Notes, 18:413-416.

Harper, F. 1931. Physiographic and faunal areas in the Athabasca and Great Slave Lake region. Ecology, 12:18-32.

Hensley, M. M., and J. B. Cope. 1951. Further data on the removal and repopulation of the breeding birds in a spruce-fir forest community. Auk, 68:483-493.

Hickey, J. J. 1937. Report of the field work committee, 1936-37. Abst. Proc. Linn. Soc., N.Y., 49:73-83.

Hildén, O. 1965. Habitat selection in birds. Ann. Zool. Fenn., 2:53-75.

Howard, E. 1920. Territory in bird life. Cox and Wyman Ltd., London. 239 p.

Howell, J. C. 1951. Roadside census as a method of measuring bird populations. Auk, 68:334-357.

Karplus, M. 1952. Bird activity in the continuous daylight of Arctic summer. Ecology, 33:129-134.

Kendeigh, C. S. 1944. Measurement of bird populations. Ecol. Monog., 14:67-106.

_______________ 1945. Community selection by birds on the Helderberg Plateau of New York. Auk, 62:418-436.

_______________ 1947. Bird population studies in the coniferous forest biome during a spruce budworm outbreak. Ontario Dept. Lands and Forests, Biol. Bull. 1. 100 p.

_______________ 1961. Animal Ecology. Prentice Hall, N.Y. 468 p.

Kendrew, W. G., and B. W. Currie. 1955. The climate of central Canada. Queen's Printer, Ottawa. 194 p.

[illegible]

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[illegible]

[illegible]

[illegible]

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[illegible]

[illegible]

[illegible]

Kluyver, H. N., and L. Tinbergen. 1953. Territory and the regulation of density in titmice. Arch. Neerl. Zool., 10:265-289.

Lack, D. 1937. A review of bird census work and bird population problems. Ibis, 1:369-395.

________ 1966. Population studies of birds. Clarendon Press, Oxford. 341 p.

Lack, D., and L. S. V. Venables. 1939. The habitat distribution of British birds. J. Animal Ecol., 8:39-71.

Lay, D. W. 1938. How valuable are woodland clearings to bird life? Wilson Bull., 50:254-256.

Leopold, A. 1942. A raptor tally in the northwest. Condor, 44:37-38.

Lewin, V. 1963. Reproduction and development of young in a population of California Quail. Condor, 65:249-278.

Linsdale, J. M. 1924. A method of showing relative frequency of occurrence of birds. Condor, 30:180-184.

MacArthur, R. H., and J. W. MacArthur. 1961. On bird species diversity. Ecology, 42:594-598.

Marshall, A. J. 1938. Bird and animal activity in the Arctic. J. Animal Ecol., 7:248-250.

Mayr, E. 1946. History of the North American bird fauna. Wilson Bull., 58:3-41.

Mehner, J. F. 1952. Notes on song cessation. Auk, 69: 466-469.

Moss, E. H. 1955. The vegetation of Alberta. Bot. Rev., 21:493-567.

Moss, E. H. 1959. Flora of Alberta. Univ. of Toronto Press. 546 p.

Naumov, R. L. 1965. Metodika absolutnogo ucheta pits u gnesdovoi period na marshrutax. [A Method of absolute census of birds on routes during nesting period.] Zool. Zhur., 46:81-93.

Nero, R. W. 1963. Birds of the lake Athabasca region, Saskatchewan. Sask. Nat. Hist. Soc., Spec. Publ. No. 5. 143 p.

Nice, M. M. 1937. Studies in the life history of the Song Sparrow. 1. A Population Study of the Song Sparrow. Trans. Linn. Soc., 4. 247 p.

Nordberg, S. 1947. Ein Vergleich zwichen Probenflächenmethode und Linientaxierungsmethode bei quantitativen Aufnahmen des Vogelbestandes. [A comparison between plot methods and line transect methods in the quantitative assessments of bird populations.] Ornis Fenn., 24:87-92.

Odum, E., and E. J. Kuenzler. 1955. Measurement of territory and home range size in birds. Auk, 72:128-137.

Oosting, H. G. 1956. The study of plant communities. 2nd ed. W. H. Freeman, San Francisco. 440 p.

Palmgren, P. 1931. Einige quantitative Vogelbestandaufnahmen aus Muonio, Lappland. [A quantitative evaluation of bird populations from Muonio, Lapland.] Ornis Fenn., 8:73-84.

Palmgren, P. 1933. Die Vogelbestände zweier Wäldchen, nebst Bemerkungen über die Brutreviertheorie und zur quantitativen Methodik bei Vogelbestandaufnahmen. [The bird populations of two small wooded areas, and remarks concerning the territory of birds and methods of censuses.] Ornis Fenn., 10:61-94.

____________ 1935. Über den Tagesrhythmus der Vögel im arktischen Sommer. [The daily rhythm of birds in the arctic summer.] Ornis Fenn., 12:107-121.

____________ 1949. On the diurnal rhythm of activity and rest in birds. Ibis, 91:561-576.

Parnell, G. F., and T. L. Quay. 1964. The summer birds of the Toxaway River Gorge of southwestern North Carolina. Wilson Bull., 76:138-146.

Pettingill, O. S. 1961. A Laboratory and Field Manual of Ornithology. Burgess Publ. Co., Minneapolis. 381 p.

Péwé, T. L. 1957. Permafrost and its effects on life in the north. In Arctic Biology. 18th Biology Colloquium. Oregon State College, Corvallis. p. 12-25.

Pianka, E. R. 1966. Latitudinal gradients in species diversity: a review of concepts. Am. Nat., 100:33-46.

Pitelka, F. A. 1941. Distribution of birds in relation to major biotic communities. Am. Midl. Nat., 25:113-137.

Remmert, H. R. 1964. Über den Tagesrhythmus arktischer Tiere. [Daily rhythm in arctic animals.] Z. Morph. Ökol. Tiere, 55:142-160.

Rodgers, T. L., and C. G. Sibley. 1940. Frequency of occurrence of birds on the Berkeley Campus, University of California. Condor, 42:203-206.

Rowe, J. S. 1959. Forest regions of Canada. Dept. of North. Affairs and Natural Res., Ottawa. Bull., 123. 71 p.

Salt, G. W. 1957. An analysis of avifaunas in the Teton Mountains and Jackson Hole Wyoming. Condor, 59:373-393.

Saunders, A. A. 1948. The season of bird song: the cessation of song after the nesting season. Auk, 65:19-30.

Scheer, G. 1952. Beobachtungen und Untersuchungen über die Abhängigkeit des Frühgesanges der Vögel von inneren und ausseren Faktoren. [Observations and investigations on the internal and external factors upon which early morning singing depends.] Biol. Abhandl., 3:3-68.

Siivonen, L. 1948. Quantitative bird survey and the short-term fluctuations in numbers. Ornis Fenn., 25:37-56.

Shelford, V. E. ed. 1945. Bird distribution and ecological concepts. A Symposium. Wilson Bull., 57:243-252.

__________ 1963. The ecology of North America. Univ. of Illinois Press, Urbana. 610 p.

Snyder, D. P. 1950. Bird communities in the coniferous forest biome. Condor, 52:17-27.

Southwood, T. R. E. 1966. Ecological methods. Butler and Tanner Ltd., London. 391 p.

Stewart, R. E. 1955. Contributor to nineteenth breeding bird census. Aud. Field Notes, 9:415-416.

Stewart, R. E., and J. W. Aldrich. 1951. Removal and repopulation of breeding birds in a spruce-fir community. Auk, 68:471-482.

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[illegible]

[illegible]

[illegible]

[illegible]

Stewart, R. E., and J. W. Aldrich. 1952. Ecological studies of breeding bird populations in northern Maine. Ecology, 33:226-238.

Tenouvo, R. 1966. Veränderungen in der Vogelfauna von Kökar (Aland, Südwestfinland) in den Jahren 1925-1961. [Changes in the avifauna of Kökar in Aland, southwest Finland from 1925 to 1961.] Ann. Zool. Fenn., 3:4-19.

Tompa, F. S. 1962. Territorial behaviour: the main controlling factor of a local Song Sparrow population. Auk, 79:687-697.

____________ 1964. Factors determining the numbers of Song Sparrows Melospiza melodia (Wilson) on Mandarte Island, B. C., Canada. Acta Zool. Fenn., 109:1-73.

Turček, F. J. 1956. On the bird population of the spruce forest community in Slovakia. Ibis, 98:24-33.

Udvardy, M. D. F. 1957. An evaluation of quantitative studies in birds. Cold Spring Harbor Symposia on Quantitative Biology, 22:301-311.

Verner, J., and M. F. Willson. 1966. The influence of habitats on mating systems of North American passerine birds. Ecology, 47:143-147.

Viereck, L. A. 1965. Relationship of white spruce to lenses of perennially frozen ground, Mount McKinley National Park, Alaska. Arctic, 18:262-267.

Weeden, S. J. 1965. Territorial behaviour of the Tree Sparrow. Condor, 67:193-209.

Welty, J. C. 1962. The life of birds. W. B. Saunders Co., Philadelphia. 546 p.

White, K. A. 1942. Frequency of occurrence of summer birds at the University of Michigan Biological Station. Wilson Bull., 54:204-210.

Williamson, S. L., M. C. Thompson, and J. Q. Hines. 1966. Avifaunal Investigations, p. 437-480. In J. W. Wilimovsky and J. N. Wolfe, [ed.], Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Comm. Oak Ridge, Tennessee.

APPENDIX I

Average weights of the passerine birds nesting on the plots. Weight averages were based on records of specimens in the Zoology Department, University of Alberta (Edmonton).

Species	Number of birds	Average Weight
Traill's Flycatcher	2	12 g
Boreal Chickadee	7	11 g
American Robin	10	88 g
Hermit Thrush	6	30 g
Swainson's Thrush	10	31 g
Gray-cheeked Thrush	2	29 g
Ruby-crowned Kinglet	6	6 g
Bohemian Waxwing	5	58 g
Tennessee Warbler	10	9 g
Myrtle Warbler	10	12 g
Blackpoll Warbler	4	12 g
Palm Warbler	1	10 g
White-winged Crossbill	2	25 g
Slate-colored Junco	10	19 g
Chipping Sparrow	10	12 g
Lincoln's Sparrow	10	16 g
Song Sparrow	9	22 g

APPENDIX II

Formulae used for the statistical analysis of the census result.

A. Distance to nearest neighbor method used to test spatial relationships in populations (Clark and Evans, 1954).

$$\bar{r}_A = \frac{\Sigma r}{N} \qquad R = \frac{\bar{r}_A}{\bar{r}_E}$$

$$\bar{r}_E = \frac{1}{2\sqrt{\rho}}$$

B. The 2 x 2 contigency table used to calculate Chi-square and coefficient of interspecific association (Southwood, 1966).

Species	Species A Present	Absent	Total
Present	a	b	a+b
Absent	c	d	c+d
Total	a+c	b+d	
		n = a+b+c+d	

C. Modified Chi-square (Southwood, 1966).

$$\text{Chi-square} = \frac{n\left[\,|ad-bc| - \frac{n}{2}\,\right]^2}{(a+c)\ (b+d)\ (a+b)\ (c+d)}$$

D. Formula used to calculate coefficient of interspecific association when ad≥bc (Cole, 1947).

$$C_{AB} = \frac{ad - bc}{(a+b)\ (b+d)} \pm \sqrt{\frac{(a+c)\ (c+d)}{n(a+b)\ (b+d)}}$$

APPENDIX III

Transient and summer birds recorded at Yellowknife, N.W.T., in 1956 and 1960 by Mr. William McDonald, and at Rae, N.W.T. in 1966, by myself, with approximate dates of arrival when available. Observations began 7 April, 10 April and 9 May, respectively. Residents and winter visitors are also included in this list.

Abbreviations are as follows:

CB - common breeder; CM - common migrant; RM - rare migrant; CSM - common spring migrant; RFM - rare fall migrant; RSM - rare spring migrant; WV - winter visitor; R - rare; Res - resident.

Common Name	Species	Status	1956 Yellowknife	1960 Yellowknife	1966 Rae
Common Loon	*Gavia immer*	CB	May 15	May 23	May 26
Yellow-billed Loon	*Gavia adamsii*	CSM	-	May 23	-
Arctic Loon	*Gavia arctica*	CB	-	May 23	-
Red-throated Loon	*Gavia stellata*	CB	May 20	May 23	-
Red-necked Grebe	*Podiceps grisegena*	CB	-	-	May 15
Horned Grebe	*Podiceps auritus*	CB	-	-	May 14
Whistling Swan	*Olor columbianus*	CM	May 23	-	-
Canada Goose	*Branta canadensis*	CB	May 1	Apr. 28	May 11
White-fronted Goose	*Anser albifrons*	CM	-	-	-
Snow Goose	*Chen hyperborea*	CM	-	-	-
Mallard	*Anas platyrhynchos*	CB	May 1	Apr. 27	May 9
Pintail	*Anas acuta*	CB	May 1	May 8	May 9
Green-winged Teal	*Anas carolinensis*	CB	-	May 1	May 9
American Widgeon	*Mareca americana*	CB	-	May 8	May 9
Shoveler	*Spatula clypeata*	CB	-	-	May 21
Ring-necked Duck	*Aythya collaris*	CB	May 9	-	May 21
Canvas-back Duck	*Aythya valisineria*	R	-	-	-
Greater Scaup	*Aythya marila*	CB	-	-	-
Lesser Scaup	*Aythya affinis*	CB	May 9	May 8	May 15

continued

APPENDIX III (continued)

Common Name	Species	Status	1956 Yellowknife	1960 Yellowknife	1966 Rae
Common Goldeneye	_Bucephala clangula_	CB	-	May 1	May 17
Bufflehead	_Bucephala albeola_	CB	-	May 23	-
Oldsquaw	_Clangula hyemalis_	CM	-	May 23	May 27
Harlequin Duck	_Histrionicus histrionicus_	R	-	-	-
Common Eider	_Somateria mollissina_	RSM	-	-	-
King Eider	_Somateria spectabilis_	RSM	-	-	-
White-winged Scoter	_Melanitta deglandi_	CM	-	June 4	May 28
Surf Scoter	_Melanitta perspicillata_	CB	May 20	June 4	May 27
Hooded Merganser	_Lophodytes cucullatus_	R	-	-	-
Common Merganser	_Mergus merganser_	CB	May 20	May 19	May 16
Red-breasted Merganser	_Mergus serrator_	CB	May 20	May 23	May 14
Goshawk	_Accipiter gentilis_	Res	-	-	-
Sharp-shinned Hawk	_Accipiter striatus_	CB	-	May 8	May 11
Red-tailed Hawk	_Buteo jamaicensis_	CB	May 10	-	May 16
Rough-legged Hawk	_Buteo lagopus_	CM	May 7	May 1	-
Golden Eagle	_Aguila chrysaetos_	R	May 20	-	-
Bald Eagle	_Haliaeecetus leucocephalus_	CB	Apr. 7	Apr. 11	May 10
Marsh Hawk	_Circus cyaneus_	CB	May 7	May 20	May 11
Osprey	_Pandion haliaetus_	R	-	-	-
Gyrfalcon	_Falco rusticolus_	WV	-	-	-
Peregrine Falcon	_Falco peregrinus_	R	-	-	-
Pigeon Hawk	_Falco columbarius_	CB	May 10	June 4	May 14
Sparrow Hawk	_Falco sparverius_	CB	May 9	May 8	May 11
Spruce Grouse	_Canachites canadensis_	Res	-	-	-
Ruffed Grouse	_Bonasa umbellus_	R	-	-	-
Willow Ptarmigan	_Lagopus lagopus_	WV	-	-	-
Rock Ptarmigan	_Lagopus mutus_	WV	-	-	-
Sharp-tailed Grouse	_Pedioecetes phasianellus_	Res	-	-	-
Sandhill Crane	_Grus canadensis_	CB	May 7	-	May 17
Sora Rail	_Porzana carolina_	CB	-	June 16	-
Semipalmated Plover	_Charadrius semipalmatus_	CB	-	-	-

continued

APPENDIX III (continued)

Common Name	Species	Status	1956 Yellowknife	1960 Yellowknife	11966 Rae
Killdeer	Charadrius vociferus	R	-	-	May 10
Black-bellied plover	Squatarola squatarola	CM	-	May 26	-
Ruddy Turnstone	Arenaria interpres	RM	-	-	-
Common Snipe	Capella gallinago	CB	May 9	May 13	May 12
Whimbrel	Numenius phaeopus	RM	-	-	-
Spotted Sandpiper	Actitis macularia	CB	May 27	-	May 29
Solitary Sandpiper	Tringa solitaria	CB	-	-	-
Lesser Yellowlegs	Totanus flavipes	CB	May 20	May 8	May 11
Knot	Calidris canutus	RM	-	-	-
Pectoral Sandpiper	Erolia melanotos	CM	May 27	-	-
White-rumped Sandpiper	Erolia fuscicollis	RM	-	-	-
Baird's Sandpiper	Erolia bairdii	CM	-	-	-
Least Sandpiper	Erolia minutella	CM	-	-	-
Dunlin	Erolia alpina	RM	-	-	-
Stilt Sandpiper	Micropalama himantopus	CM	-	-	-
Semipalmated Sandpiper	Ereunetes pusillus	CM	-	-	-
Buff-breasted Sandpiper	Tryngites subruficollis	RM	-	-	-
Hudsonian Godwit	Limosa haemastica	RM	-	-	-
Sanderling	Crocethia alba	CM	-	-	-
Red Phalarope	Phalaropus fulicarius	CM	-	-	-
Northern Phalarope	Lobipes lobatus	CM	-	-	-
Parasitic Jaeger	Stercorarius parasiticus	CB	-	-	-
Long-tailed Jaeger	Stercorarius longicaudus	RM	-	-	-
Herring Gull	Larus argentatus	CB	Apr. 30	Apr. 28	May 12
California Gull	Larus californicus	CB	-	May 10	May 12
Ring-billed Gull	Larus delawarensis	R	-	-	-
Mew Gull	Larus canus	CB	May 10	May 9	-
Bonaparte's Gull	Larus philadelphia	CB	May 19	-	-
Glaucous Gull	Larus hyperboreus	RFM	-	May 15	-
Common Tern	Sterna hirundo	R	-	-	-
Arctic Tern	Sterna paradisaea	CB	May 19	June 10	May 27

continued

APPENDIX III (continued)

Common Name	Species	Status	1956 Yellowknife	1960 Yellowknife	1966 Rae
Caspian Tern	_Hydroprogne caspia_	R	May 19	June 10	-
Great-horned Owl	_Bubo virginianus_	Res	-	-	-
Snowy Owl	_Nyctea scandiaca_	CM	-	-	-
Hawk Owl	_Surnia ulula_	R	-	-	-
Short-eared Owl	_Asio flammeus_	CM	May 20	-	-
Common Nighthawk	_Chordeiles minor_	CB	-	-	May 31
Belted Kingfisher	_Megaceryle alcyon_	CB	-	-	May 19
Yellow-shafted Flicker	_Colaptes auratus_	CB	-	June 4	May 10
Pileated Woodpecker	_Dryocopus pileatus_	R	-	-	-
Yellow-bellied Sapsucker	_Sphyrapicus varius_	R	-	-	-
Hairy Woodpecker	_Dendrocopos villosus_	CB	-	-	May 11
Black-backed Three-toed Woodpecker	_Picoides arcticus_	Res	-	-	-
Northern Three-toed Woodpecker	_Picoides tridactylus_	Res	-	-	-
Eastern Kingbird	_Tyrannus tyrannus_	CB	-	-	-
Eastern Phoebe	_Sayornis phoebe_	CB	-	-	-
Yellow-bellied Flycatcher	_Empidonax flaviventris_	R	-	-	-
Traill's Flycatcher	_Empidonax traillii_	CB	June 7	-	-
Least Flycatcher	_Empidonax minimus_	CB	June 7	-	-
Olive-sided Flycatcher	_Nuttallornis borealis_	CB	-	-	-
Horned Lark	_Eremophila alpestris_	CM	May 10	May 8	May 20
Tree Swallow	_Eridoprocne bicolor_	CB	May 10	May 13	May 12
Bank Swallow	_Riparia riparia_	CB	-	-	-
Barn Swallow	_Hirundo rustica_	CB	May 19	May 28	-
Cliff Swallow	_Petrochelidon pyrrhonota_	CB	May 23	June 8	-
Gray Jay	_Perisoreus canadensis_	Res	-	-	-
Common Raven	_Corvus corax_	Res	-	-	-
Common Crow	_Corvus brachyrhynchos_	R	Apr. 20	Apr. 12	-
Black-capped Chickadee	_Parus atricapillus_	R	-	-	-
Boreal Chickadee	_Parus hudsonicus_	Res	-	-	-

continued

APPENDIX III (continued)

Common Name	Species	Status	1956 Yellowknife	1960 Yellowknife	1966 Rae
Robin	Turdus migratorius	CB	May 10	May 9	May 11
Hermit Thrush	Hylocichla guttata	CB	May 10	-	-
Swainson's Thrush	Hylocichla ustulata	CB	-	June 3	May 23
Gray-cheeked Thrush	Hylocichla minima	CB	-	-	-
Mountain Bluebird	Sialia currucoides	R	Apr. 11	-	May 10
Golden-crowned Kinglet	Regulus satrapa	R	-	-	-
Ruby-crowned Kinglet	Regulus calendula	CB	-	-	June 8
Water Pipit	Anthus spinoletta	CM	May 20	-	May 12
Bohemian Waxwing	Bombycilla garrula	CB	May 7	-	May 14
Northern Shrike	Lanius excubitor	CB	May 10	-	May 10
Starling	Sturnus vulgaris	R	-	-	-
Solitary Vireo	Vireo solitarius	R	-	-	-
Tennessee Warbler	Vermivora peregrina	CB	June 1	-	-
Orange-crowned Warbler	Vermivora celata	CB	-	May 22	-
Yellow Warbler	Dendroica petechia	CB	May 23	May 22	May 29
Myrtle Warbler	Dendroica coronata	CB	May 20	May 22	May 17
Black-throated Green Warbler	Dendroica virens	R	-	-	-
Black-polled Warbler	Dendroica striata	CB	-	-	May 31
Palm Warbler	Dendroica palmarum	CB	June 7	-	-
Northern Water Thrush	Seiurus noveboracensis	CB	May 27	-	-
Wilson Warbler	Wilsonia pusilla	R	-	-	-
English Sparrow	Passer domesticus	R	-	-	-
Red-winged Blackbird	Agelaius phoeniceus	CB	May 15	-	May 12
Rusty Blackbird	Euphagus carolinus	CB	May 15	-	May 12
Western Tanager	Piranga ludoviciana	R	-	-	-
Rose-breasted Grosbeak	Pheucticus ludovicianus	R	-	-	-
Pine Grosbeak	Pinicola enucleator	R	-	-	-
Hoary Redpoll	Acanthis hornemanni	WV	-	-	May 25
Common Redpoll	Acanthis flammea	WV	-	-	-
Red Crossbill	Loxia curvirostra	R	-	-	-
White-winged Crossbill	Loxia leucoptera	Res	-	-	May 14

continued

APPENDIX III (continued)

Common Name	Species	Status	1956 Yellowknife	1960 Yellowknife	1966 Rae
Savannah Sparrow	_Passerculus sandwichensis_	CB	May 23	June 3	May 13
Slate-colored Junco	_Junco hyemalis_	CB	May 10	May 8	May 10
Tree Sparrow	_Spizella arborea_	CM	May 15	May 15	May 12
Chipping Sparrow	_Spizella passerina_	CB	May 20	May 27	May 14
Clay-colored Sparrow	_Spizella pallida_	R	-	-	May 14
Harris' Sparrow	_Zonotrichia querula_	CM	May 19	May 22	May 12
Gambel's Sparrow	_Zonotrichia leucophrys_	CB	May 10	May 8	May 11
White-throated Sparrow	_Zonotrichia albicollis_	CB	May 27	-	May 13
Fox Sparrow	_Passerella iliaca_	CB	May 15	May 15	May 20
Lincoln's Sparrow	_Melospiza lincolnii_	CB	May 20	May 22	May 13
Swamp Sparrow	_Melospiza georgiana_	CB	-	-	-
Song Sparrow	_Melospiza melodia_	CB	May 27	-	-
Lapland Longspur	_Calcarius lapponicus_	CM	May 15	May 13	May 16
Smiths Longspur	_Calcarius pictus_	CM	May 15	-	-
Snow Bunting	_Plectrophenax nivalis_	CM	Apr. 13	Apr. 10	-

(Names follow the A.O.U. Check-list, 1957)